

**REMEDIAL INVESTIGATION/FEASIBILITY STUDY
UNITED STATES COAST GUARD
OLD BASE
ST. LOUIS, MISSOURI**

**Contract No. DTCG83-99-D-3CL038
Task Order No. 0538**

Prepared for:

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LIST OF ACRONYMS

AST	Aboveground Storage Tank
bgs	below ground surface
BTEX	Benzene, Toluene, Ethylbenzene, Xylene
CALM	Cleanup Levels for Missouri
CEU	Civil Engineering Unit
cm/sec	centimeters per second
DNAPL	Dense Non-aqueous Phase Liquid
DRO	Diesel Range Organic
EDP	EDP Consultants
GRO	Gasoline Range Organic
HRC	Hydrogen Release Compounds
HSA	Hollow Stem Auger
IDW	Investigation-Derived Waste
KNO ₃	Potassium Carbonate
KOH	Potassium Hydroxide
µg/kg	microgram per kilogram
µg/L	micrograms per liter
MNA	Monitored Natural Attenuation
MSL	Mean Sea Level
MWH	MWH Americas, Inc.
MWQS	Missouri Water Quality Standards
NAFA	Non-Appropriated Fund Activities
NaOH	Sodium Hydroxide
NGVD	National Geodetic Vertical Datum
ORC	Oxygen Release Compound
PCB	Polychlorinated Biphenyl
PCE	tetrachloroethene
PID	Photoionization Detector
ppm	parts per million
PVC	Polyvinyl Chloride
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
Sq. ft	Square Feet
SVE	Soil Vapor Extraction
SVOCs	Semi-Volatile Organic Compounds
TCE	Trichloroethene
TRPH	Total Residual Petroleum Hydrocarbons
USCG	United States Coast Guard
UST	Underground Storage Tank
VOC	Volatile Organic Compounds

1.0 INTRODUCTION

MWH Americas, Inc. (MWH) was retained by the United States Coast Guard (USCG), Civil Engineering Unit (CEU) Miami to perform a Remedial Investigation/Feasibility Study (RI/FS) at the USCG facility, Old Base, St. Louis, Missouri. MWH's effort included performing a site inspection, site wide soil and groundwater assessment, aboveground storage tank survey (AST), asbestos survey and transformer dielectric fluid sampling and analysis. The asbestos survey was completed at the Industrial Building, Service Building, and Non-Appropriated Fund Activities (NAFA) Building at the facility. The findings of asbestos survey were summarized in a separate report entitled *Asbestos Survey Report, USCG Old Base St. Louis, March 2002* (MWH, 2002). This RI/FS Report incorporates new information as well as information from previous environmental studies of the site. This work was performed under MWH's Contract No. DTCG83-99-D-3CL038, Task Order No. 0538.

1.1 Project Purpose and Scope

The overall objective of the RI/FS is to obtain sufficient data regarding the nature and extent of contamination at Old Base St. Louis to allow selection of a remedial strategy for the site. The USCG is considering a probable sale of the property. This RI/FS report was completed to provide a summary of the remedial investigation results and present potential remedial options for the facility. The investigation activities included:

- defining the extent of contamination in soil and groundwater;
- determining the hydraulic properties of the site, including depth to groundwater, groundwater flow direction, and hydraulic conductivity; and
- developing feasible remedial alternatives by evaluating the fate and transport of contaminants and measuring the effects of natural attenuation processes.

1.2 General Investigation Approach

The RI consisted of collecting soil samples from four soil borings and installing four temporary wells for groundwater sampling. A total of eight borings/temporary wells was

planned, but only four were installed due to site conditions. The location of the USCG site is depicted in Figure 1-1.

One boring was located east of boring number 13, which was completed in 1992 during a Phase II Environmental Evaluation. Three borings were completed to the north, east and west of monitoring well MW-9, which was installed during the Phase II evaluation. Soil and groundwater samples from these locations were analyzed for volatile organic compounds (VOCs), total recoverable petroleum hydrocarbons (TRPH), and total metals. Four borings were planned in locations around the hydraulic sump, which is located in the southwest corner of the industrial building. However, these borings/wells were not installed since no tank was present.

In addition to the four borings, nine existing groundwater monitoring wells, installed during the Phase II Environmental Evaluation, were sampled. Groundwater samples from these nine wells were analyzed for VOCs and natural attenuation parameters (i.e., nitrogen, sulfide, sulfate, nitrate, total organic carbon, alkalinity, iron, manganese, and phosphorus). During the groundwater investigation, hydraulic conductivity tests were performed in two of the existing Phase II monitoring wells and a potentiometric survey of the groundwater wells was performed. The groundwater analytical results were interpreted using fate and transport modeling (BIOCHLOR) to determine if natural attenuation is occurring at Old Base St. Louis. The results of the fate and transport modeling were used to refine remedial alternatives that are feasible for the site.

In conjunction with the RI/FS activities, two other tasks were completed. The first of these tasks consisted of sampling oil from the on-site electrical transformer and analyzing it for polychlorinated biphenyl (PCB) content. The second task consisted of draining the hydraulic sump, located in the southwest corner of the industrial building, and properly disposing of its contents off site.

2.0 FACILITY BACKGROUND INFORMATION

2.1 Site Location

The USCG Old Base St. Louis, Missouri is located at Mile 173.6 on the West Bank of the Upper Mississippi River in an urbanized, predominately industrial and commercial area. Figure 2-1 shows the location of the base in relation to the surrounding area as depicted on USGS Quadrangle Map. The facility comprises an area of approximately 4.43 acres, measuring 345 feet along the western boundary, 600 feet on the southern boundary, and 457 feet along the northern side. The eastern boundary, measuring 372 feet long, parallels the Mississippi River. The riverbank, at 418 feet above mean sea level (MSL), is rip-rapped (EDP, 1991). The facility is bounded on the north by Alumax aluminum metal fabricators, on the west by railroad tracks and a Southern Metals Processing facility (scrap metal), and to the south by Brenntag, a specialty chemical manufacturer/distributor. Figure 2-2 depicts the layout of the USCG site and the surrounding property.

2.2 Land Usage

2.2.1 Current Land Usage

Old Base St. Louis is currently an inactive facility, aside from the occasional inspection, grounds maintenance, and nightly patrols by a security service. Utilities, including natural gas, water, and electricity have been taken out of service. The Base was closed in 1993 as a result of severe flooding of the Mississippi River. Prior to closure of the facility, some of the Coast Guard duties performed there consisted of: stocking, issuing, and shipping aids to navigation material; providing mooring facilities for Coast Guard vessels; maintaining, repairing, and modifying boats, vehicles, engines, shore-based machinery, and aids to navigation equipment; performing repair and modifications to machinery and electronic equipment on Coast Guard vessels; supporting the District Disaster Control Organization; and operating NAFA facilities. The buildings that currently exist at the site consist of an industrial building on the north side of the

property, a barracks facility to the east, and a boat storage shed, exchange club and NAFA building to the south (see Figure 2-2).

Old Base St. Louis formerly contained two 8,000-gallon gasoline underground storage tanks (USTs), one 500-gallon diesel UST, and one tank of unknown capacity under the EM Club Building. The tanks have subsequently been removed. Previous investigations of the property did not indicate adverse impacts as a result of tank operations. There are presently two approximately 200-gallon petroleum ASTs located at the southeast corner of the industrial building.

The site is located within a industrialized section of St. Louis. The site is located east of a scrap yard that recycles aluminum and ferrous metals. The Missouri Pacific Railroad tracks separate the Base from Southern Metal Processing's scrap yard. North of the Base is Alumax Foils (subsidiary of Alcoa), which manufactures aluminum-faced paper insulating sheet, and smelts aluminum from the scrap yard west of the Base. A chemical plant owned by Brenntag AG is located south of the Base and the Mississippi River is east of the site (Figure 2-2).

* In recent years several accidental spills have occurred at the Brenntag property causing considerable groundwater contamination at the USCG Old Base St. Louis. There is no chemical manufacturing on the Brenntag property. A few products are blended prior to shipment. Liquid chemicals handled at the site include acids, caustic, aromatic solvents, ketones, and chlorinated solvents. Chemicals are stored at the Brenntag facility in AST and in the warehouse in drums. There are no active UST or piping for products at the facility (EDP, 1991). The layout of the Brenntag facility is also depicted in Figure 2-2.

2.2.2 Future Land Use

The USCG is attempting to excess the Old Base St. Louis property. Future uses of the property are unknown at this time, but are likely to remain industrial.

2.3 Site History

The USCG purchased the property in two separate declarations in 1941 and 1944. Prior to this, a steel mill dating back to World War I previously occupied the property. Between 1951 and 1953, most of the wartime buildings were replaced by the present Industrial Building, and a large open Boat Storage Building. The facility, the title of which was changed from Depot to Base in 1956, was first acquired to provide support for many World War II naval vessels constructed on the Western River System. Since World War II, the station has been primarily involved in aids to navigation, logistics, and industrial support.

The Industrial Building was constructed in 1953. It is approximately 22,500 square feet (sq. ft) and was used to house the public works, electronics, shops, base office, shipping and receiving, clothing lockers, and storage space. This building is presently scheduled for asbestos abatement and demolition. The NAFA building was constructed in 1943. It is approximately 2,500 sq. ft. In December 1963, the barracks building was destroyed by fire and was replaced in 1965 by a 3,600 sq. ft, 50-man barracks-subsistence building. The boat shed is a galvanized steel prefabricated building built in 1951. The service club was constructed in 1970 and is also a metal prefabricated building. In 1978, the base operations and security building was constructed.

During the summer of 1993, the Old Base St. Louis was flooded by the Mississippi River and was submerged under four feet of water. Due to the damage caused by the flood, a decision was made to close the Base in late 1993. The Base has been inactive since its closure.

2.4 Previous Investigations

In 1991 and 1992, Phase I and II Environmental Site Investigations were performed by EDP Consultants (EDP) at Old Base St. Louis. These evaluations were performed to assess the type, extent, magnitude, and possible origin of the contamination identified during an investigation performed previously by ATEC Associates in March 1991.

2.4.1 Phase I Environmental Evaluation

The Phase I Environmental Evaluation was conducted to assess the type of work performed at the site and the type of materials stored on base. This phase of the evaluation consisted of a site walk, file reviews, and personnel interviews. A Phase I report was submitted to the USCG (EDP, 1991) and is summarized below.

A survey of the tanks previously and presently on site showed that, at the time of the assessment, four USTs and one AST for the storage of fuel were in service. One 500-gallon diesel UST was in service, two 8,000-gallon gasoline USTs were inactive, and a 2000-gallon diesel UST was removed in 1986. The AST on site was a 500-gallon gasoline tank. Other materials found to be stored on site were small quantities of polyvinyl chloride (PVC) cement, paints, paint remover, and insecticide spray. A paint locker was used as storage for these chemicals. Any paint waste and paint residue was allowed to evaporate from cans stored inside the locker. The remaining residue was placed in a 55-gallon drum located in the hazardous waste storage building located at the west end of the boat storage building. The other 55-gallon drums located in the hazardous waste storage building contained oily bilge water from tugboats. The other remaining storage of hazardous waste on site was an AST containing waste engine oil collected during boat maintenance activities.

During the site walk, observations of the riverbank revealed a black stained seam that extended across the entire bank. Small holes were observed in the concrete that stabilizes the slope of the bank. From these small holes, streaks of residue could be seen where seepage of a dark liquid had stained the concrete. Just south of the boom dock, a dark liquid was seeping from one of the holes. The liquid quickly sank and did not leave an oily sheen on the surface. A sample collected from the leachate, which had a chlorinated solvent odor, had an approximate pH between 11 and 12.

File reviews were done to determine how the property was used prior to being owned by the USCG. Studies of aerial photographs, title searches, and historical record searches confirmed that the property was previously owned by the Mississippi Valley Iron Company. Other evidence of previous property usage was not discovered.

A survey of the tanks located on the Chemtech Industries property (property now owned by Brenntag AG) was performed. The tank locations, tank capacities, and types of materials stored were determined. Several 250,000- and 350,000-gallon ASTs were located near the south perimeter of the base with about 30 smaller tanks, of 2,500- to 3,000-gallon capacity, located to the south of the larger tanks. The contents of the large tanks are high pH materials, primarily caustic soda, sodium hydroxide (NaOH), potassium carbonate (KNO₃), and potassium hydroxide (KOH). The smaller tanks contained a variety of solvents including acetone, benzene, toluene, trichloroethylene, and xylene, some of which were detected in the soil boring collected by ATEC in March 1991.

The Phase I Evaluation indicated the possibility that offsite usage of hazardous materials had affected the quality of the soil and groundwater at the USCG base. The Phase I Evaluation also discussed the possibility that a five foot diameter underground pipe was present under the site. EDP discovered this "possible migration pathway" reviewing St. Louis City Hall Building Department records (EDP, 1991). A Phase II Environmental Evaluation was conducted to evaluate possible offsite impacts to the site.

2.4.2 Phase II Environmental Evaluation

The Phase II Environmental Evaluation was performed to assess the subsurface conditions at the Base. At the time of the Phase II evaluation, the USTs identified during the Phase I had been removed. The main driving factor for the Phase II was the leachate seeping from the west bank of the Mississippi River. The Phase II investigation included soil and groundwater sampling and analytical testing.

During the investigation, a total of 17 soil borings were drilled and nine of the borings were completed as permanent monitoring wells. The Phase II soil boring locations are depicted in Appendix A. The analytical results from the Phase II investigation indicated that elevated concentrations of petroleum and chlorinated solvent based compounds were present in four soil borings, B-4, B-6, B-9, and B-16. The compounds included benzene, 2-butanone, dichloroethane isomers, dichlorobenzene isomers, ethylbenzene, tetrachloroethene, toluene, and xylene. The VOCs detected in samples from B-4 and B-9 appeared to correspond with those compounds detected in the sample previously collected by ATEC. Several other samples had detected concentrations of VOCs. Residual concentrations of TRPH and benzene, toluene, ethylbenzene, and xylene (BTEX) were detected in borings B-13 and B-15, which were completed at former UST locations. However, it was concluded by EDP that the concentrations of BTEX detected in these soil boring samples were not indicative of requiring further remediation. Tables that present the Phase II soil data are presented in Appendix A.

Groundwater samples were collected from the nine monitoring wells installed during the Phase II evaluation. Groundwater analytical results from the monitoring wells are presented in Appendix B. Benzene was detected at concentrations exceeding the action level in seven of nine wells. Toluene, ethylbenzene, and xylene were also detected in a majority of the wells on site. From the data, it appeared that the BTEX was entering the south side of the Base from two separate areas of the Brenntag site. Other compounds including acetone, dichloroethene isomers, trichloroethene, and dichlorobenzene isomers were detected in most of the groundwater samples. Overall, the highest levels of contaminants were detected in monitoring wells MW-4 and MW-9 which are located on the south side of the base, adjacent to the Brenntag AG property. Based on the groundwater results, there was sufficient evidence to suspect that a spill or series of spills may have occurred at the tank car transfer point located near the southwest corner of the site, at points along the aboveground transfer pipeline, and at the ASTs located on the Brenntag property (EDP, 1992).

EDP noted in the conclusion of the Phase II Report that several potential sources of offsite contamination are present including the Mississippi Valley Iron Company and ChemTech Industries (Brenntag). It was summarized in the cover letter to the Phase II Report that the "low concentrations of hydrocarbons are not sufficient to have caused the magnitude of the problem now known to exist at the site" (EDP, 1992).

2.5 Site Geology and Hydrogeology

Soil borings from previous investigations revealed a subsurface profile consisting primarily of coarse granular fill overlying gray silt followed by limestone bedrock. The fill is composed of slag, gravel, bricks, paving stones, and foundry sand. Trace amounts of coal and glass were also noted in the fill. These fill deposits were reported to be porous (EDP, 1992). The fill thickness ranged from 0 to 32 feet below ground surface (bgs) with depths increasing to the east toward the Mississippi River (EDP, 1992).

Below the fill at an approximate depth of 25 feet bgs is a layer of gray silt which was deposited in the floodplain of the Mississippi River. The silt thickness ranges from 5 to 10 feet, and overlies the St. Louis Limestone, the uppermost local bedrock unit. Wells were installed at depths above this layer because it was suspected that the silt would not yield sufficient water (EDP, 1992). Bedrock at the site slopes down from northwest to southeast across the site. The bedrock ranges from an approximate elevation of 393.8 feet above MSL at the northwest corner of the site to 384.6 feet at the southeast corner of the site. The average depth to the bedrock across the site is about 32 feet bgs. The bedrock topography was contoured in the Phase II Investigation (EDP, 1992). This contour map is included in Appendix A. A slight depression is apparent in the vicinity of MW-11. The bedrock topography may exert control on the groundwater flow and transport of contaminants.

A review of the Phase I and II data and data from the RI/FS suggest that there may be differing hydrogeological zones at the site. As noted above, the silt layer is a relatively low permeability layer. The aquifer slug testing data collected at the site yielded

relatively high values for hydraulic conductivity. Thus, there is inferential evidence of differing hydraulic conductivity due to a differing aquifer matrix. This is also suggested from an evaluation of the water levels collected at the site, where there is a drastic difference in depths to water.

Groundwater flow at Old Base was found to be in the easterly direction toward the Mississippi River. Bedrock slopes to the east and southeast toward the Mississippi River. Groundwater flows through the upper fill, above the silt that overlies the bedrock. The silt and clay that overlies the bedrock along the floodplain of the river acts as a lower confining layer. Cross-sections and soil boring logs of the area prepared by EDP Consultants during their 1992 Phase II Site Investigation are provided in Appendix A.

Groundwater surface elevations were measured during the MWH Remedial Investigation (RI) on February 18, 2002. Table 2-1 presents the summary of the February 2002 groundwater measurements for the USCG site. During this same period Arcadis Geraghty and Miller (Arcadis) was performing quarterly groundwater sampling at the Brenntag facility. As per the request of MWH, Arcadis supplied copies of the Brenntag analytical results and groundwater elevation data. While not the typical approach, these groundwater elevation data were combined with Old Base St. Louis data to estimate potentiometric groundwater surface elevation during this period. Appendix C provides a summary of the groundwater elevations collected by Arcadis. Figure 2-3 depicts the estimated groundwater potentiometric surface elevation as measured in on-site (Phase II) wells on February 18, 2002. As can be seen in Figure 2-3, groundwater flow is in a northeastern direction, towards the Mississippi River. A potentiometric surface map was also prepared from compiled water levels from the USCG (MWH, February 2002) and the Brenntag site data (Arcadis, February 2002). This is presented as Figure 2-4. An estimated hydraulic gradient of 0.02 was calculated from the Potentiometric Surface Map (Figure 2-4). The hydraulic gradient was calculated from groundwater levels between MW-6 and MW-10. The groundwater flow direction and hydraulic gradient compare to

data collected by Arcadis. Groundwater elevation data and analytical results from Arcadis are presented in Appendix C.

3.0 REMEDIAL INVESTIGATION SAMPLING ACTIVITIES

In February 2002, a RI/FS was performed at Old Base St. Louis by MWH. The RI/FS involved collecting soil and groundwater samples from four locations (soil borings/temporary wells) at the USCG property, collecting groundwater samples from the nine existing Phase II monitoring wells at the site, performing hydraulic conductivity tests in two of these Phase II monitoring wells, and completing a potentiometric survey of the Phase II groundwater wells at the Base. In addition to the RI activities, the oil from the electrical transformer on site was sampled and analyzed for PCBs and the suspected hydraulic sump on site was scoped to be emptied of its contents and properly disposed of at an off site location. This was not performed since a sump containing a hydraulic tank was not present.

3.1 Soil and Groundwater Investigation

3.1.1 Soil Borings and Temporary Well Installation

Initially, eight soil borings were to be completed at Old Base St. Louis using direct push techniques as outlined in the Site Work Plan (MWH, 2002). However, the borings were completed using hollow-stem-auger (HSA) techniques, because direct push techniques were not effective for the geological conditions at the site. Per the initial Scope of Work, one boring was to be located east of boring number 13, completed in 1992 during a Phase II Environmental Evaluation. Three borings were scoped to be completed to the north, east and west of monitoring well MW-9, which had been installed during the Phase II evaluation. These three borings were installed during the RI. The last four borings were to be completed around the hydraulic sump located in the southwest corner of the industrial building. These four borings were not installed during the RI since a sump containing a hydraulic tank was not present.

The DP-4 soil boring was completed using a 6.25-in outer diameter HSA east of boring Number 13. The remaining three soil borings were completed in the specified locations around MW-9. The location of the soil borings/temporary wells is depicted in Figure 3-1.

The soil samples were collected with a 2-foot split-spoon sampler that was advanced into the soil through the HSA. The sampler was advanced in five-foot intervals until the apparent saturated zone was reached. Soils were screened with a photoionization detector (PID) and placed in the appropriate clean, labeled, laboratory-supplied container in accordance to the methods described in the Site Work Plan (MWH, 2001). Soil samples were analyzed for VOCs, TRPHs, total metals, and pH. A summary of the RI soil analytical data is presented in Table 3-1. The laboratory soil analytical reports are presented in Appendix D.

Once the soil borings were advanced to the proper depth, temporary wells were installed through the HSAs. The temporary well was constructed of 1-inch inside diameter, flush-threaded, Schedule 40 PVC, completed with a 10-foot section of screen. After installation, the temporary well was developed prior to sampling. Groundwater samples were collected from the temporary well using disposable bailers. The groundwater samples were placed directly into laboratory-supplied containers and immediately placed in a cooler containing ice. Care was exercised when obtaining the VOC samples to ensure no headspace existed in the sample containers. The temporary well screen and casing was removed at the completion of field activities and the borehole abandoned in accordance with Missouri Well Construction Rules.

Three soil borings, DP-1 through DP-3, were advanced to the north, east and west of MW-9 using the same drilling and installation techniques described above. However, no soil or groundwater samples were collected for DP-1, as an obstruction was hit at an approximate depth of 8 feet bgs in DP-1. Because of the poor soil recovery from the split-spoon sampler and the refusal of the HSAs, no soil samples could be collected. An offset from this location was attempted, but refusal was again encountered at approximately 10 feet bgs.

Four additional soil borings were to be completed around the hydraulic sump located in the southwest corner of the industrial building. During the initial site walk, an assessment of the sump area was performed. Due to the location of the sump and the Industrial Building, the soil borings were to be located upgradient of the sump, which would provide limited information on the effects of the sump on the soil and groundwater conditions surrounding the sump. Also, the sump was empty and appeared to be connected to the air conditioning condensate piping system as opposed to being a hydraulic sump. Based on these observations, the sump did not appear to be a threat of contamination to the soil or groundwater at the site. Therefore a decision was made to eliminate the four soil borings surrounding the sump.

The locations of the soil borings, DP-1 through DP-4, are presented on Figure 3-1. Appendix E contains Boring Logs, Well Construction Diagrams, and Well Development Logs for these borings/temporary wells.

3.1.2 Groundwater Monitoring Well Sampling

During the Phase II Environmental Evaluation, nine groundwater wells were installed. As part of the groundwater portion of the RI, the nine (Phase II) monitoring wells were sampled for VOCs and natural attenuation parameters. The natural attenuation parameters included permanent gases, metabolic acids, and metals/nutrients. The Phase II wells were gauged with an oil/water interface probe prior to sampling. Each monitoring well was then purged. Purging was accomplished by removing groundwater from the monitoring wells using a dedicated bailer. Purging was carried out until either, the water quality parameters including pH, temperature, conductivity, and turbidity stabilized and at least three well volumes had been removed, or the well was pumped dry. Following purging, groundwater samples were collected using the same disposable bailer used during purging. Each sample was placed in laboratory-supplied containers. Groundwater sampling logs are provided in Appendix F. The laboratory groundwater analytical data reports are presented in Appendix G.

3.1.3 In-Situ Hydraulic Conductivity Tests

The RI included determining the hydraulic properties of the upper aquifer at Old Base St. Louis. Hydraulic conductivity tests were performed in two of the existing wells, MW-4 and MW-11. The tests were performed using the methodology described in the Site Work Plan (MWH, 2002). A 5-ft stainless steel slug tool was used to displace water and an In-situ Hermit 2000 Datalogger and pressure transducer were used to record time and drawdown measurements. Static water level at the start of the slug-in test was set as the reference point. The displaced volume of the slug tool was approximately 0.3125 gallons. The slug-in tests correspond to a falling head test and the slug-out tests to a rising head test. Hydraulic conductivity and transmissivity for each well was estimated using the Bower and Rice method. The raw data and the Bower and Rice time vs. drawdown graphs are presented in Appendix G. The calculated hydraulic conductivity for each well is summarized below.

Well ID	Hydraulic Conductivity Foot/sec	Hydraulic Conductivity cm/sec	Transmissivity gal/day/foot
<i>Rising Head Test</i>			
MW-4	4.77E-03	1.46E-01	92,560
MW-11	1.97E-03	6.00E-02	38,185
<i>Falling Head Test</i>			
MW-4	3.31E-03	1.01E-01	64,095
MW-11	3.33E-03	1.01E-01	64,508

3.2 HYDRAULIC SUMP AND TRANSFORMER SAMPLING

As discussed in section 4.1.1, the hydraulic sump was empty and was observed to be a part of the air conditioning system rather than a hydraulic sump. Therefore, there was no need to pump out the contents of the sump.

A General Electric Energy Services technician was subcontracted to collect the transformer sample. The technician collected the sample in laboratory-supplied bottles

and submitted the samples for analysis. The results of this sampling are summarized in Table 3-2

3.3 SURVEYING

A survey of the existing onsite wells was conducted by MWH on February 28, 2002. The results of the survey are summarized in Table 3-3. The wells were referenced to a USGS benchmark, located at the northwest corner of the site. The benchmark was marked as 422.78 feet NGVD.

4.0 REMEDIAL INVESTIGATION RESULTS AND DISCUSSION

4.1 SOIL ANALYTICAL RESULTS

Various VOCs, TRPHs, and metals were detected in the temporary well soil samples collected during the MWH RI/FS. A summary of the RI soil analytical results is presented in Table 3-1. Each bold entry on Table 3-1 indicates that the analyte is detected above the detection limit. The VOCs detected included: benzene, n-butylbenzene, chlorobenzene, 1,4-dichlorobenzene, ethylbenzene, isopropylbenzene, naphthalene, n-propylbenzene, tetrachloroethene (PCE), toluene, trichloroethene (TCE), 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, and total xylenes. The maximum detected compound in soil was 1,2,4-trimethylbenzene at a concentration of 677,000 µg/kg in DP-2 from the 20-22 foot bgs interval. The maximum naphthalene detected in soil was 492,000 µg/kg in DP-2 from the 20-22 foot bgs interval. The maximum detected total xylene was 658,000 µg/kg in DP-3 from 20-22 ft bgs.

Gasoline Range Organics (GRO) and Diesel Range Organics (DRO) were detected in soil borings DP-2 and DP-3. GRO results ranged from non-detect to 2,290,000 µg/kg in DP-3 at the 20-22 ft bgs interval. DRO results ranged from non-detect to 3,760,000 µg/kg in soil boring DP-3 at the 20-22 ft bgs interval. Only DRO was detected in soil boring DP-4 at the 4 to 6 foot interval at a concentration of 18,800 µg/kg. Metals detected in soil samples included arsenic, barium, cadmium, chromium, lead, and selenium. The range of pH for the soil samples was 6.2 to 12.2. Most of the pH results are on the basic side (greater than 8.0). The maximum detected soil pH was 11.7 in soil boring DP-2 in the 25-27 foot bgs interval. The maximum detected soil pH of 12.2 in soil boring DP-3 in the 25-27 foot bgs interval. The maximum detected soil pH was 8.9 in soil boring DP-4 in both the 2-4 and the 6-8 foot bgs intervals. The high pH levels likely correspond to the caustic soda release by Brenntag.

For comparative purposes, the soil data was compared to Cleanup Levels for Missouri (CALM) Tier I Soil Cleanup Standards. The CALM soil standard and soil analytical results are presented on Table 3-1. A non-residential scenario (Scenario C) was chosen as a screening criteria. Using the CALM screening criteria, the following analytes exceeded criteria:

SAMPLE	ANALYTE	CALM CRITERIA	RESULT
DP-2	naphthalene	240,000	492,000
20-22 ft bgs	1,2,4-trimethylbenzene	76,000	677,000
	total xylenes	418,000	610,000
DP-3	naphthalene	240,000	369,000
20-22 ft bgs	1,2,4-trimethylbenzene	76,000	510,000
	total xylenes	418,000	658,000

4.2 INVESTIGATION-DERIVED WASTE ANALYTICAL RESULTS

The RI generated three drums of soil Investigation-Derived Waste (IDW) and three drums of liquid IDW. Grab samples of solid IDW were collected from the three soil drums and analyzed for toxicity characteristic leaching procedure (TCLP) VOCs, TCLP SVOCs, and TCLP Metals. A summary of the analytical results is provided in Table 4-1. The solid IDW had detectable concentrations, in micrograms per liter ($\mu\text{g/L}$), of chlorobenzene (50), chloroform (20), PCE (80), and TCE (40) and (80). Barium was the only metal detected in the IDW sample DP-4 at a concentration of 1,000 $\mu\text{g/L}$.

The groundwater analytical results were used to characterize the liquid IDW. Groundwater analytical data indicate that there were detectable VOCs above Missouri Water Quality Standards (MWQS). Based the detection of VOCs in groundwater and VOCs and barium in soil, MWH recommends disposing of the six IDW drums to an appropriate offsite facility. The IDW disposal manifest is provided as Appendix H.

4.3 GROUNDWATER ANALYTICAL RESULTS

4.3.1 Existing Groundwater Well Analytical Results

Handwritten mark: A stylized 'A' or 'X' with a horizontal line through it.

The nine on-site (Phase II) monitoring wells were sampled by MWH on February 21, 2002. These samples were submitted to Test America, located in Nashville, Tennessee and analyzed for VOCs and metals. In addition, groundwater samples were also submitted to Keystone Laboratories, located in Newton, Iowa and analyzed for natural attenuation parameters. Table 4-2 summarizes the groundwater analytical results from the February 2002 groundwater sampling event. The VOCs detected MWQS included: vinyl chloride, methylene chloride, cis-1,2-dichloroethene, benzene, TCE, toluene, PCE, chlorobenzene, ethylbenzene, total xylenes, 1,2-dichlorobenzene, and naphthalene. These compounds were detected in MW-9, which is located closest to the property boundary. Benzene was detected, in µg/L, in MW-4 (231), MW-6 (30.0), MW-7 (67.8), MW-9 (570), MW-10 (56.6), and MW-12 (58.0). PCE, in µg/L, was detected in MW-9 (968) and in MW-11 (14.0). Cis-1,2-dichloroethene, in µg/L, was detected in MW-4 (12,500), MW-7 (136) and MW-9 (4,000). Vinyl chloride, in µg/L, was detected in MW-4 (1,900), MW-7 (23.2), MW-9 (188), MW-10 (2.9) and MW-12 (2.9).

4.3.2 Temporary Well Analytical Results

The temporary well groundwater analytical results are summarized in Table 4-3. The VOCs detected above MWQS included: benzene, chlorobenzene, 1,2-dichloroethane, cis-1,2-dichloroethene, ethylbenzene, methylene chloride, naphthalene, PCE, toluene, TCE, vinyl chloride, and total xylenes. The breakdown products (e.g., vinyl chloride and cis-1,2-dichloroethene) of PCE via reductive dechlorination are present in DP-2 and DP-3. Benzene was detected in DP-2, DP-3 and DP-4 at concentrations of 772 µg/L, 436 µg/L, and 0.69J µg/L respectively. Cis-1,2-dichloroethene was detected in DP-2, DP-3 and DP-4 at concentrations of 842 µg/L, 2,100 µg/L and 16.4 µg/L respectively. Ethylbenzene was detected in DP-2, DP-3 and DP-4 at concentrations of 2,220 µg/L, 3,960 µg/L, and 4 µg/L, respectively. Naphthalene was detected in DP-2, DP-3 and DP-4 at concentrations of 3,220 B µg/L, 4,480 B µg/L, and 15.1 B µg/L, respectively.

4.3.3 Transformer Analytical Results

The results of the transformer sampling are provided in Appendix I. The analytical results of the transformer sample are summarized in Table 3-2. The PCB found in the sample was 87 part per million (ppm). This value is greater than the regulatory definition of 50 ppm. The Federal Register, Vol. 44 No. 106, May 31, 1979, defined a PCB contaminated transformer as one containing 50 ppm to 500 ppm PCB. Methane and ethane were present in the transformer sample at levels above IEEE limits. These IEEE limits are related to the servicability of the transformer.

4.4 Aquifer Testing and Data Reduction

The aquifer testing data was reduced using equations derived by Bower and Rice. The procedures for conducting the tests are discussed in Section 3.1.3. The estimated hydraulic conductivity from the rising head aquifer test for MW-4 was 1.45×10^{-1} centimeters per second (cm/sec) and 6.00×10^{-2} cm/sec for MW-11. The falling head aquifer test yielded similar results of 1.00×10^{-1} cm/sec for MW-4 and 1.01×10^{-1} cm/sec for MW-11.

These hydraulic conductivity values are relatively high and in the range of well-sorted sands or well-sorted gravel. The upper fill coarse fill material underlying the site may contribute to these relatively fast values for the hydraulic conductivity.

4.5 Soil and Groundwater Summary

Figures 4-1 depicts a BTEX plume with a source area outside of the USCG property boundary. The BTEX plume measures 320 feet long by 270 feet wide. The source well of the BTEX plume appears to originate from Brenntag's MW-14. The BTEX plume is restricted at USCG MW-8 and USCG MW-10. The plume bends around USCG MW-8 and USCG MW-10 towards USCG MW-7 and USCG MW-4.

Figure 4-2 depicts a chlorinated solvent plume approximately 320 feet long by 360 feet wide. The chlorinated solvent plume appears to have a source area located at Brenntag, ~~MW-2~~. The plume geometry is configured in the same shape as the BTEX plume, with a bend at USGC wells MW-8 and MW-10. As discussed in Section 2.5, the slope of the bedrock at USGC MW-11 may be contributing to the shape of the BTEX and chlorinated solvent plumes.

Both the BTEX and chlorinated solvent plumes have source areas outside of the USGC property boundary. This is a significant factor in the following two sections of the report which discuss the fate and transport of chemicals of concern and remedial strategies.

5.0 FATE AND TRANSPORT MODELING

Natural attenuation generally describes a range of physical and biological processes which, unaided by deliberate human intervention, reduce the concentration, toxicity, or mobility of chemical or radioactive contaminants. These processes take place whether or not other active clean-up measures are in place.

The plume maps presented in Figures 4-1 and 4-2 show both hydrocarbon (Total BTEX) plumes and total chlorinated solvent plumes, respectively. These figures utilize data collected from both MWH during the RI/FS and Arcadis (Brenntag). Fate and transport modeling was conducted for chlorinated VOCs since they are more recalcitrant to remediation. Most of the remedial technologies discussed in the following Section 6.0 will treat the chlorinated solvents in groundwater and provide substantial reduction of hydrocarbon compounds. Selected groundwater analytical results were input into the BIOCHLOR model. This fate and transport model is a screening-level simulation of natural attenuation of chlorinated compounds via reductive dechlorination. In reductive dechlorination, the chlorinated hydrocarbon is used as an electron acceptor, not as a source of carbon, and a chlorine atom is removed and replaced with a hydrogen atom (USEPA, 1998). Preliminary site data were entered into the USEPA screening protocol and it indicated that the aquifer characteristics are adequate for monitored natural attenuation (MNA) at the site. Not all of the geochemical parameters necessary for the protocol were analyzed, so not every natural attenuation protocol could be put into the preliminary screening protocol for natural attenuation. Nonetheless, the preliminary data yielded a score of 16, indicative of adequate evidence of biodegradation of chlorinated organics.

The typical pathway for the breakdown of PCE is as follows: $\text{PCE} \rightarrow \text{TCE} \rightarrow \text{DCE} \rightarrow \text{Ethene}$. This is graphically illustrated in Figure 5-1. BIOCHLOR incorporates concentrations of these compounds for modeling. Further, the following hydrogeologic data were used:

INPUT PARAMETER	VALUE USED
Effective Porosity (n)	0.30
Hydraulic Conductivity (K)	6×10^{-2} cm/sec
Hydraulic Gradient (i)	0.02
Bulk Density	1.7 kg/L
Fractional Organic Carbon (f _{oc})	0.002
Plume length	455 feet
Plume Width	280 feet
Thickness of Saturated Zone	10 feet
Source Well	Brenntag MW-2

The relatively high hydraulic conductivity of the soils (6×10^{-2} cm/sec) skews the BIOCHLOR results in terms of plume length. The BIOCHLOR MODEL using the input of 6×10^{-2} is depicted in Figure 5-2. When the chlorinated compounds are graphed, there is no decrease in concentration as a function of distance from the source. Whereas groundwater analytical results show a plume that diminishes before reaching the Mississippi River, BIOCHLOR indicates only minor reduction in chlorinated compound concentration at the River. Thus, significant decrease of chlorinated compounds does not occur before reaching the Mississippi River. Sensitivity analysis of the model and comparison with field data suggest that hydraulic conductivity may be closer to 10^{-3} or 10^{-4} cm/sec. It is recommended to conduct further aquifer slug testing at the site.

The sensitivity analysis revealed that the hydraulic conductivity data may be closer to 10^{-3} or 10^{-4} cm/sec, so a value of 8×10^{-4} was input into the BIOCHLOR model. Figure 5-3 depicts decreasing concentrations of the chlorinated compounds as a function of distance from the source. The results of the BIOCHLOR modeling suggest that more accurate aquifer testing information is necessary. The model predicts slight reductions due to biodegradation, but the hydrogeology of the site and distance to the source areas result in the plume reaching the Mississippi River before substantial biodegradation.

In addition to chlorinated compounds, groundwater analytical results exceed the MWQS for BTEX as well. Biodegradation of fuel hydrocarbons, especially BTEX, is mainly

limited by electron acceptor availability and generally will proceed until all of the contaminants biochemically accessible to the microbes are destroyed (EPA, 1998).

Further data collection and BIOSCREEN modeling of fuel-related BTEX contaminants will help to refine possible MNA strategies for the site. Groundwater samples, especially those at the Brenntag site, should be collected and analyzed for dissolved oxygen, nitrate, iron (II), sulfate, sulfide, methane, ORP, carbon dioxide, alkalinity, hydrogen, chloride, and total organic carbon. This will further refine the accuracy of the model.

6.0 REMEDIAL OPTION EVALUATION


This section discusses the development and screening of remedial action alternatives. The objective of developing alternatives is to assemble a collection of feasible remedial actions to address current site conditions. Several key features should be considered during the selection of remedial measures. These include:

- Source control actions to address the principle threat waste wherever practicable, and engineering controls, such as containment, for products that pose a relatively low long-term threat.
- Contaminated groundwaters should be returned to their beneficial use wherever practicable, within a time frame that is reasonable given the particular circumstances of the site. When restoration is not practicable, Environmental Protection Agency (EPA) expects to prevent further migration of the plume, prevent exposure to the contaminated groundwater, and evaluate further risk reduction.
- Contaminated soil should be remediated to achieve an acceptable level of risk to human and environmental receptors (OSWER Directive 9200.4-17).

The plumes depicted in Figures 4-1 and 4-2 show migrating plumes of BTEX and chlorinated compounds with source areas south of the USCG property and outside of the property boundary. The concentration of BTEX, PCE, and TCE can be expected to migrate east and southeast towards the Mississippi River based on potentiometric data. The groundwater level in this region fluctuates according the river levels. In addition, the groundwater flow direction may periodically shift with the stages of the Mississippi River. Further monitoring would be necessary to confirm this.

Based on historical data and current site conditions, four remedial alternatives were assembled for source reduction and five remedial alternatives were assembled for perimeter remediation technologies. The remedial options available to the USCG are summarized in Table 6-1. A combination of source reduction and perimeter remediation technologies will be required to effectively reduce the range and concentrations of the compounds impacting the groundwater.

6.1 SOURCE AREA REMEDIATION



The data collected in the Phase I and II ESA and in the RI support evidence that the source area of chlorinated VOCs is offsite. Thus, the USCG will have limited success in implementing and achieving Source Area Remediation. Alternatives for Source Area Remediation are provided in Section 6.1 as a reference guide for source area remedial technology.

6.1.1 Alternative 1: No Action

Alternative 1 consists of performing no remedial action for the USCG property. This alternative is the baseline condition assuming that no further remedial measures would be implemented at the site. This alternative does not meet remedial action objectives since the groundwater concentrations exceed current regulatory guidelines. Additional remedial actions will be required.

6.1.2 Alternative 2: Treated Water Injection/Amended Water Injection

Alternative 2 consists of installing wells and submersible pumps to collect impacted groundwater and pump it through a treatment system consisting of an oil water separator (if required), an air stripper, and thermal/carbon treatment for vapors (if required). The treated water from the air stripper is injected back into the ground to create a flushing effect. The flushing effect may enhance removal of additional dissolved and lightly adsorbed VOCs. Dissolved oxygen will help remove aerobically biodegradable contaminants. This alternative could require a lengthy time period and may eliminate the anaerobic mechanisms that are degrading highly chlorinated compounds. This alternative may require additional permitting from regulatory agencies.

6.1.3 Alternative 3: Amended Water Injection

Alternative 3 consists of amended water injection. The amended water injection is the same process as the treated water injection with the addition of inorganic nutrients. The increase in dissolved oxygen will help reduce aerobically biodegradable contaminants.

The nutrients can cause a limited amount of chemical oxidation to occur. The chemical oxidation is capable of degrading chlorinated and non-chlorinated compounds. Increased fouling of wells and equipment can occur with the addition of inorganic nutrients requiring additional monitoring and maintenance.

6.1.4 Alternative 4: In Situ Chemical Oxidation

Alternative 4 consists of injecting Fenton's reagent into the saturated zone to create free radicals or permanganate, which transforms and breaks down contaminants. The typical Fenton's reagents are hydrogen peroxide plus ferrous sulfate. Permanganate and sulfate can also be injected to complete chemical oxidation. Chemical oxidation creates a rapid destruction of contaminants, including free-phased contaminants. Results are usually achieved after a few injections. Increased groundwater temperature due to the reaction, can impact natural attenuation mechanisms. Also, high pressure due to off-gases can cause uncontrolled reactions. Since the groundwater pH is 7, acidification of groundwater may not be required for this site.

6.1.5 Alternative 5: Hydrogen Release Compound

Alternative 5 consists of injecting polylactate ester into the subsurface that hydrolyzes to release lactic acid and hydrogen fostering reductive dechlorination. The slow release nature of the hydrogen prompts efficient reductive dechlorination. This technology creates anaerobic zones during the dechlorination process. This technology is only applicable for the saturated zones. Multiple injections may be necessary to reduce the contaminants to acceptable regulatory levels. The dechlorination process may create by-products that include cis-1,2 dichloroethene and vinyl chloride. These by-products will require an aerobic environment to degrade.

6.2 PLUME PERIMETER REMEDIATION TECHNOLOGIES

Plume Perimeter Technologies may be options to consider at the USCG site since source area remediation is not implementable. The following sections discuss potentially viable alternatives.

6.2.1 Alternative 1: Barrier Wall

Alternative 1 requires the emplacement of reactive media, such as iron filings, into a trench transecting the plumes. This approach may effectively treat contaminants passing through the wall, thereby decreasing migration of source contaminants offsite, or decreasing contaminants migrating to the USCG property. An added benefit is that the media lifetime is permanent and requires little maintenance. Cost of the trench can be large depending on the desired depths and lengths required. Maintenance to remove scale would probably be required.

6.2.2 Alternative 2: Biosparging in Wells

Alternative 2 includes the injection of air into the saturated zones using existing monitoring wells to increase dissolved oxygen for biodegradation of BTEX, vinyl chloride, and cis-1,2-dichloroethene. The biosparging creates an aerobic environment for better biodegradation of aerobically degradable VOCs. Depending on the required pressures and flow rates this technology can be utilized in free-phase areas. Caution must be undertaken to prevent migration of free-phase constituents to offsite areas. This technology is not as feasible in low permeability zones. The technology will not treat anaerobically degradable contaminants. This technology requires an onsite system to inject the air will require operations and maintenance.

6.2.3 Alternative 3: Air Sparging into a Trench

Alternative 3 is similar to Alternative 2 except the air is injected into a trench instead of injecting through wells. The trench configuration creates an air curtain and increases dissolved oxygen. The trench operation helps to prevent offsite migration and can be used through low permeability zones to cut off any VOC migration through these areas. The cost of installing an air sparging trench is directly related to depth and length. The trenches are usually excavated, the porous piping is installed, and the trench is back filled with high permeability material. This technology requires an above ground system to supply air and will require operations and maintenance. This technology will not treat anaerobically degradable contaminants.

6.2.4 Alternative 4: Air Sparging with Soil Vapor Extraction

Alternative 4 is the same as alternative 2 with the addition of Soil Vapor Extraction (SVE). SVE is used to treat and extract contaminants in the unsaturated zones. Contaminated vapors are volatilized and stripped from the saturated zones with the air sparging. The contaminants are then transported to the unsaturated zone and removed with the SVE system. The SVE system requires installation of extraction wells and a vacuum system to collect the contaminants located in the unsaturated zones. Treatment of collected vapors may be required prior to discharging to the atmosphere. Both the air sparging and SVE systems will require operations and maintenance. This technology will not treat anaerobically degradable contaminants.

6.2.5 Alternative 5: Oxygen Release Compound

This alternative requires the addition of magnesium peroxide product to groundwater to provide slow releases of oxygen to the water-bearing zone. This technology can be injected as a slurry or placed in wells in the form of filter socks. This technology will help maintain aerobic biodegradation of VOCs. The cost of Oxygen Release Compound (ORC) increases significantly if more than two rounds of injections are required. ORC injection is most cost effective in areas without free product.

6.3 COMBINATION ALTERNATIVES

6.3.1 Alternative 1: Barrier Wall with In Situ Chemical Oxidation

Alternative 1 includes combining the Barrier Wall alternative with the In Situ Chemical Oxidation alternative. This combination was chosen so that the USCG could reduce any further migration of contaminants from source areas and reduce the concentrations of contaminants presently at the site. The barrier wall would be installed at the property boundary to minimize plume migration from offsite properties. The barrier wall will aid in treatment of the chlorinated solvents that are migrating from the source areas. The chemical oxidation would be introduced at the USCG facility. The chemical oxidation would treat any aerobically and anaerobically degradable constituents that are currently at the site. This combination alternative would accomplish short-term goals of reducing

contaminant loading at the site and would address long-term goals by reducing the pathway for plume migration from source areas from entering the USCG property.

6.3.2 Alternative 2: Air Sparging in Trench with Hydrogen Release Compounds

This alternative would require the injection of Hydrogen Release Compounds (HRC) into the saturated zones, up-gradient of the air sparging trench. This combination of technologies creates an anaerobic zone for dechlorination followed by an aerobic zone to degrade additional VOCs and dechlorination by-products. This combination alternative completes the long-term goals of minimizing additional migration from offsite areas. This combination does not reduce the current contaminant concentrations that are located down gradient of the air sparging trench. Natural Attenuation or alternate treatment technologies would be required to reduce the existing contaminant concentrations.

6.3.3 Alternative 3: Hydrogen Release Compounds with Air Sparging/SVE

This alternative would combine the injection of HRC for dechlorination and the addition of dissolved oxygen for aerobic degradation. HRC injection points would be required near the property boundary. This injection area will initiate dechlorination. The next phase would be to introduce a section of air sparging with SVE. This zone would be aerobic and allow degradation of VOCs and dechlorination by-products. The SVE would capture the contaminants out of the vadose zone. In addition to these two zones additional combination zones may be required, down gradient, to reduce the concentrations of aerobic and anaerobic degradable compounds. This alternative will address the remediation of onsite contaminants but does not address additional plume migration from the source areas.

6.4 DISCUSSION

These alternatives are potentially applicable treatment technologies that the USCG may implement to remediate the site. Since the source areas are located on adjacent parcels of property, source area removal is not an available option. Therefore, the benefits of the technologies presented may be minimal. The benefits of these technologies will only increase if source reduction and/or containment goals are achieved. Since both aerobic

and anaerobic degradable compounds are present in groundwater at the site, MWH would recommend a combination of the alternatives to assist in reducing groundwater concentrations to below current regulatory requirements. MWH is not recommending a single specific alternative because of the lack of site-specific information for each technology and because the source removal containment goals are unavailable as a remedy.

In order to generate an appropriate cleanup strategy, several factors must be considered:


- Have contaminants migrated into the limestone bedrock. If so to what extent?
- How does the hydraulic gradient react during daily or seasonal variations in the Mississippi River?
- Does Brenntag have any plans for source remediation/control?

Furthermore, MWH would recommend discussions with Brenntag to explore a cost sharing arrangement that would put the onus of the cleanup on the primarily responsible party.

7.0 RECOMENDATIONS FOR FURTHER INVESTIGATION

As mentioned in Section 5.0, further data collection will help refine development of a closure strategy and determine if MNA or if an enhanced remediation would provide more beneficial. The MNA screening protocol and the fate and transport modeling presented in this RI/FS are preliminary evaluations of site conditions, based on the currently available data. Further investigation to develop a remedial strategy is warranted.

Due to the site lithology, further investigation of the underlying limestone aquifer is recommended. If contaminants have migrated into the underlying limestone aquifer as a Dense Non-aqueous Phase Liquid (DNAPL), then a remedial strategy for the site will include a lower aquifer investigation and remediation. Previous studies indicate that the bedrock surface dips to the southeast and southwest in the vicinity of MW-11. The bedrock topography may serve to influence the transport of contaminants. Limestone contains secondary porosity features, such as fracturing, voids, and jointing that can influence groundwater flow and plume migration. The secondary porosity of limestone complicates a groundwater pathway analysis.

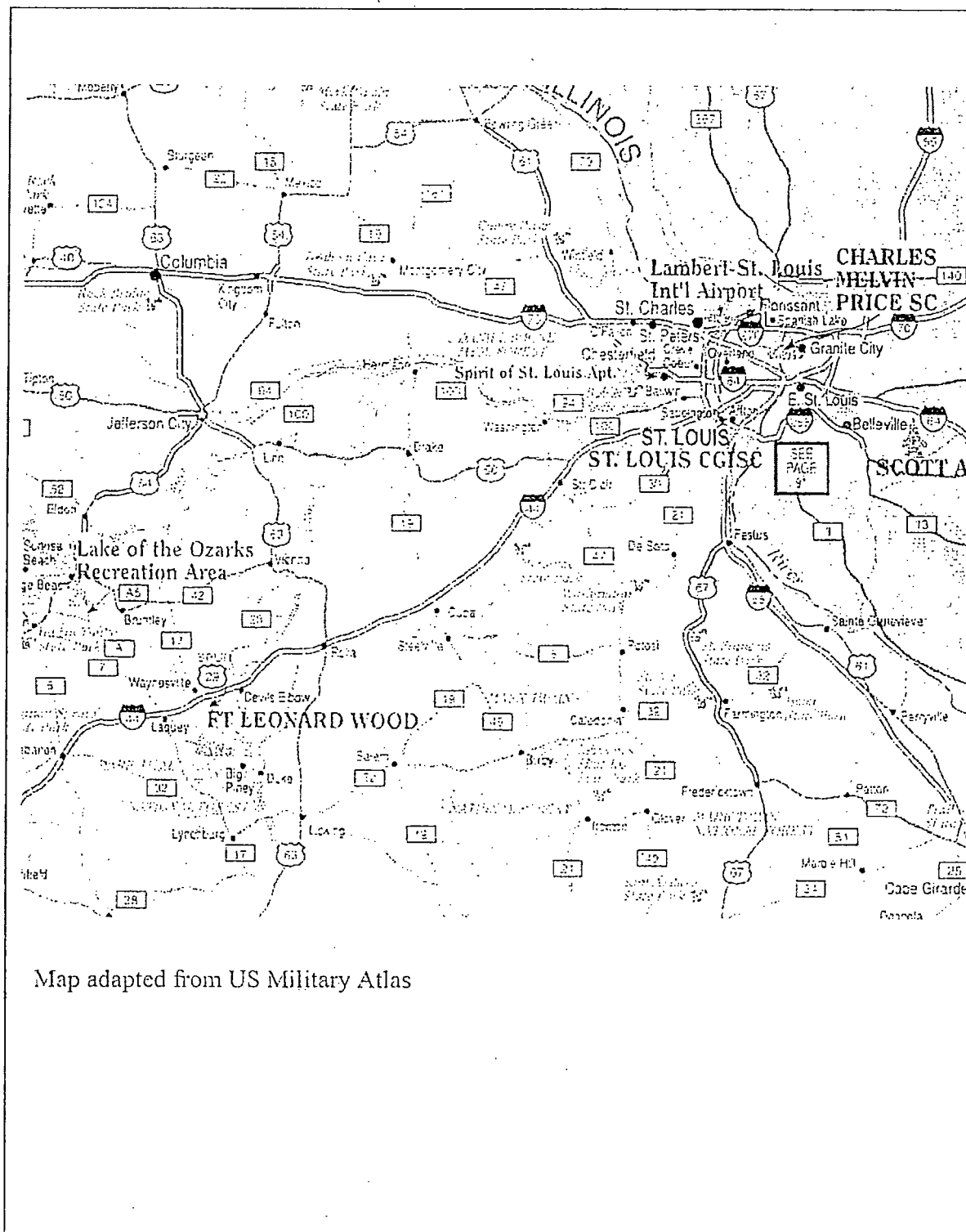
From the data collected during the Phase I, Phase II, and RI, it appears that source control alternatives may not be implementable, since the contamination source is most likely outside of the USCG property boundary. A combination plume perimeter technology and in-situ treatment may be the most useful remedial option. 

A detailed risk analysis of soil and groundwater data should be conducted to determine potential risk to human and environmental receptors. This risk analysis should determine potential receptors, perform a risk-based evaluation of the data, and develop a site-specific conceptual model.

8.0 REFERENCES

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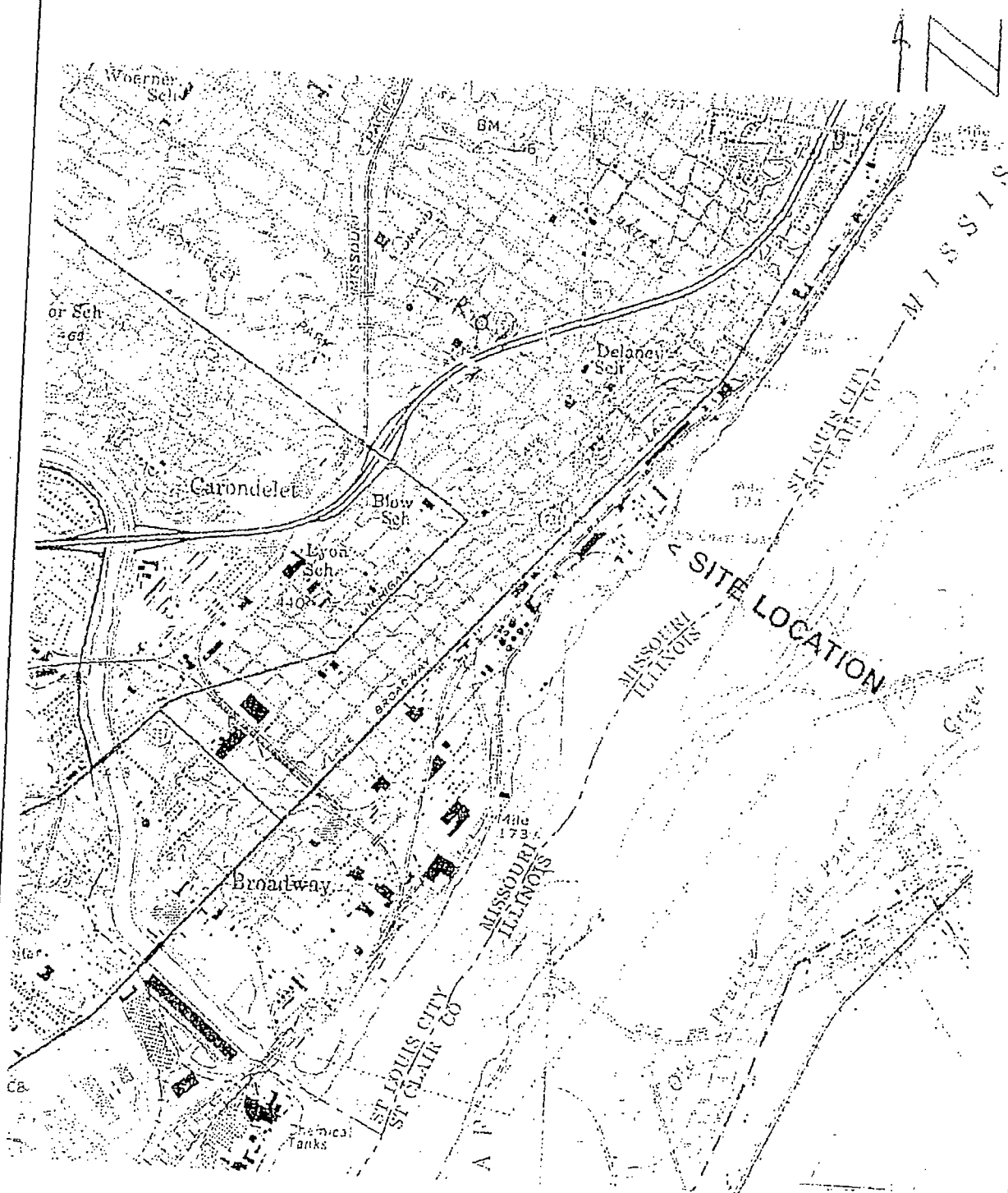
Ifo/federal/coastguard/St. Louis/RI/FS report



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FIGURE 1-1
Site Location Map



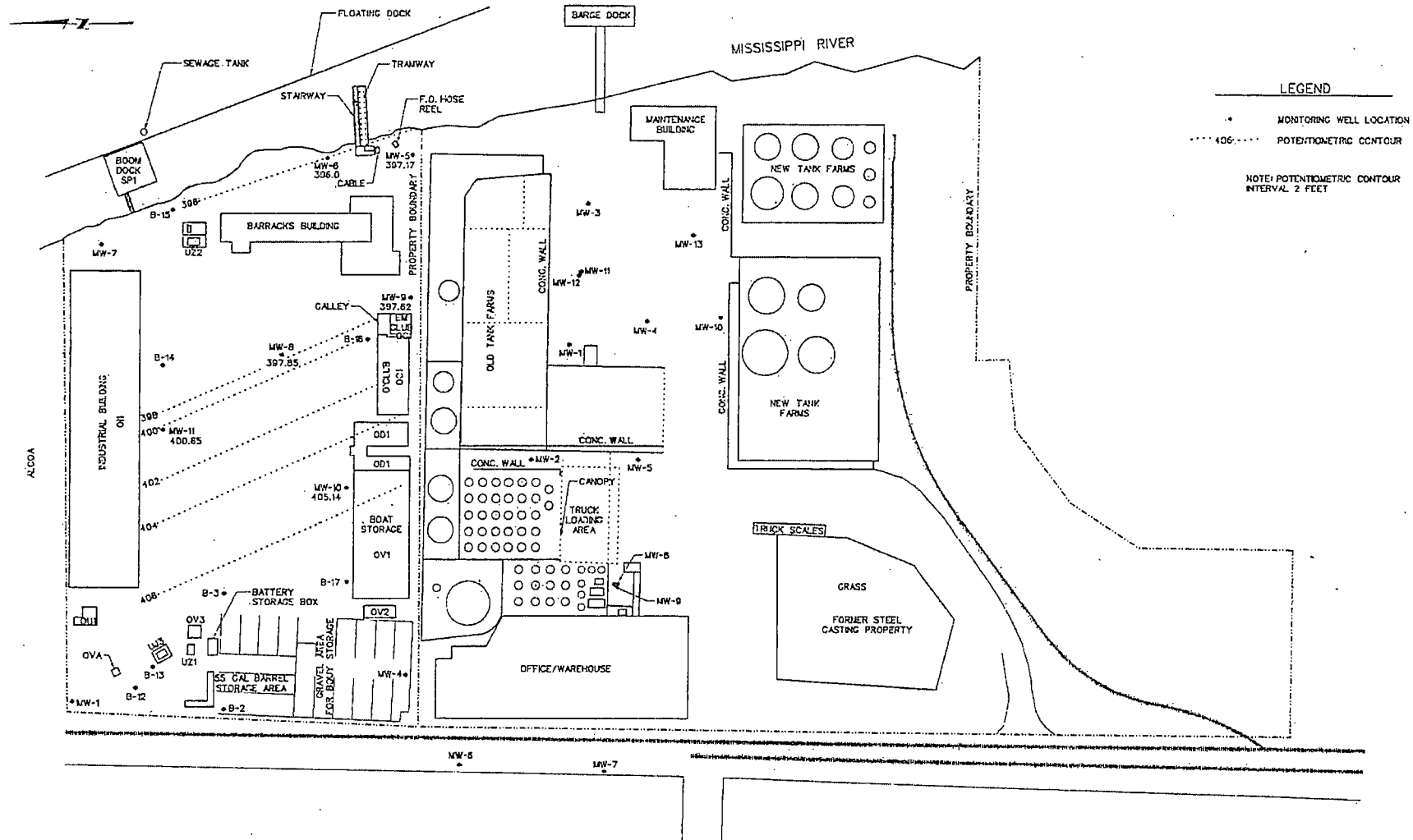
Map adapted from USGS 7.5 Minute Quadrangle
Webster Groves and Cahokia, Missouri-Illinois

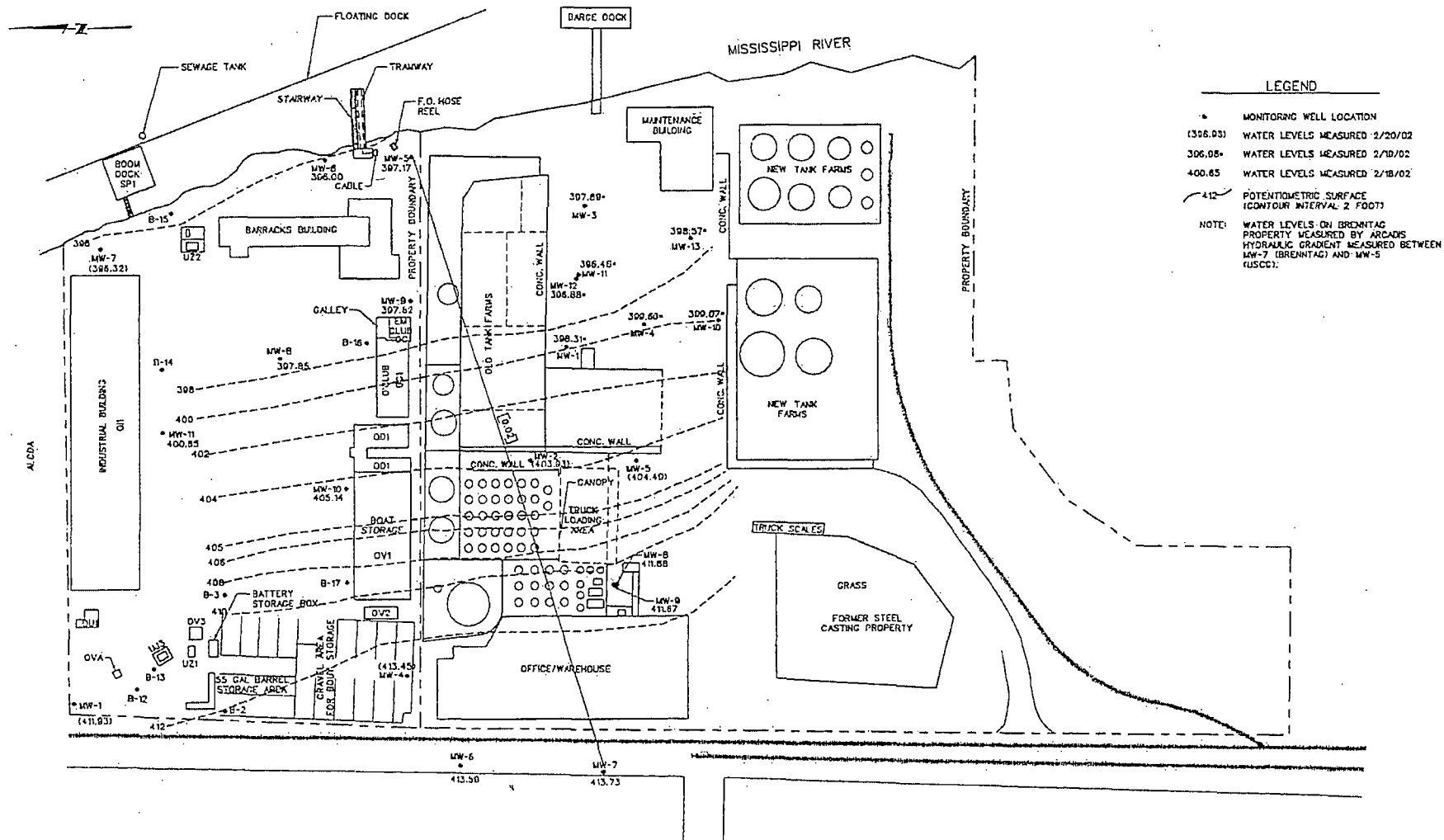


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FIGURE 2-1
Site Location Map

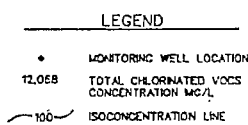




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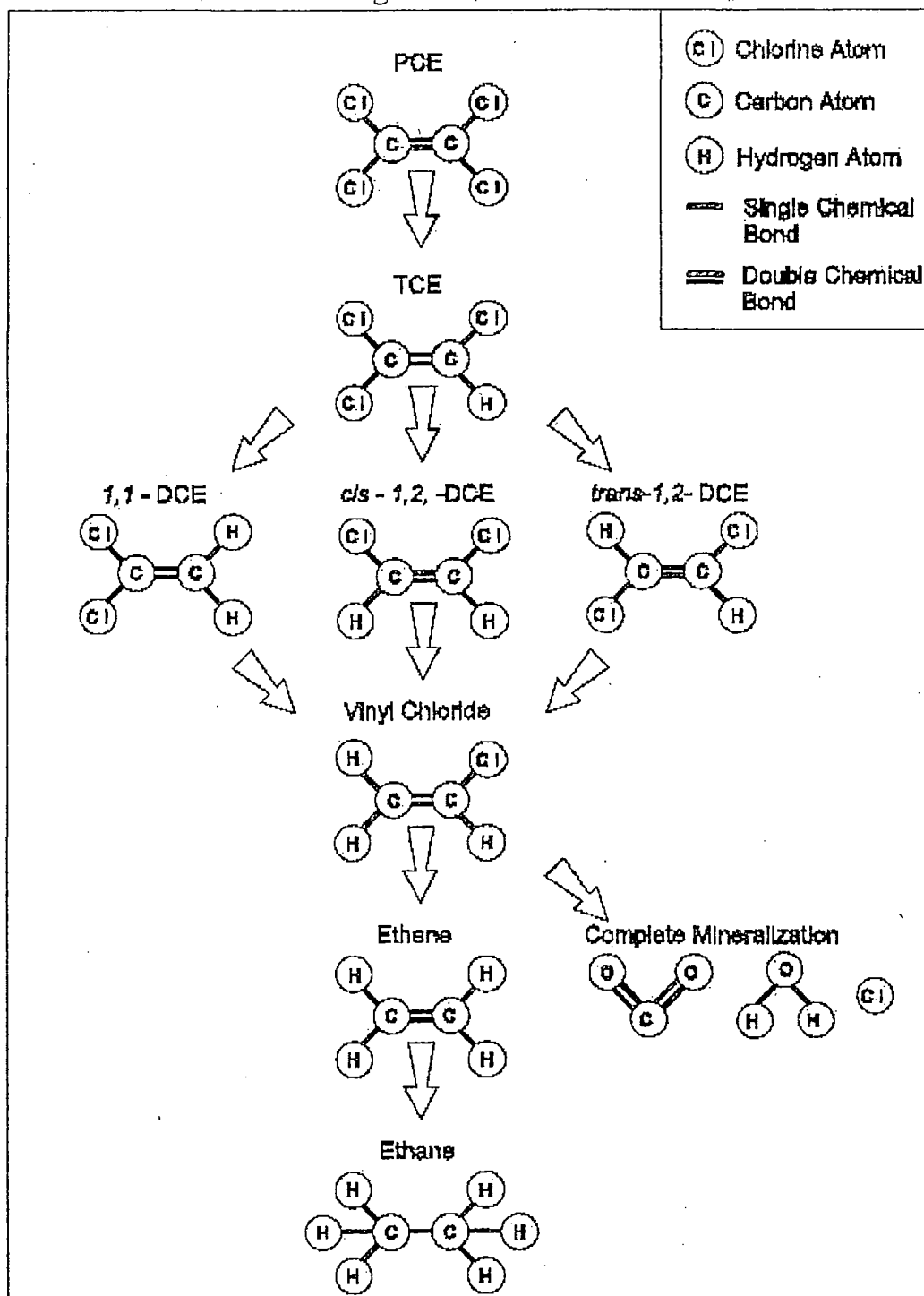


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DATE: _____ TIME: _____ DRAWN: L. JAYK CHECKED: _____ COMPANY: _____ PROJECT NO.: _____ DATE: _____ U.S. COAST GUARD BASE ST. LOUIS ST. LOUIS, MISSOURI				LOCATION OF: _____ PROJECT: _____ U.S. COAST GUARD BASE ST. LOUIS ST. LOUIS, MISSOURI				TOTAL CHLORINATED VOC: ISOCONCENTRATION MAP FEBRUARY 2002				4-2	
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Reductive dehalogenation of chlorinated ethenes



Source: EPA 600/R-98/128. Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water.



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FIGURE 5-1

Reductive Dechlorination of PCE

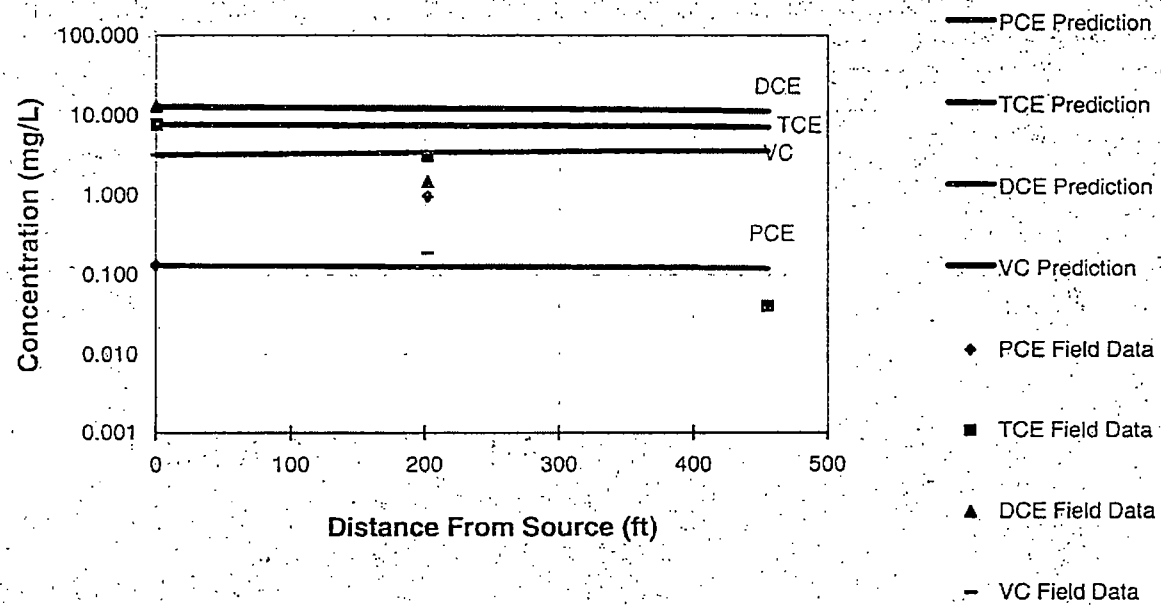


Figure 5-2. BIOCHLOR model, using field-measured hydraulic conductivity of 6×10^{-2} .

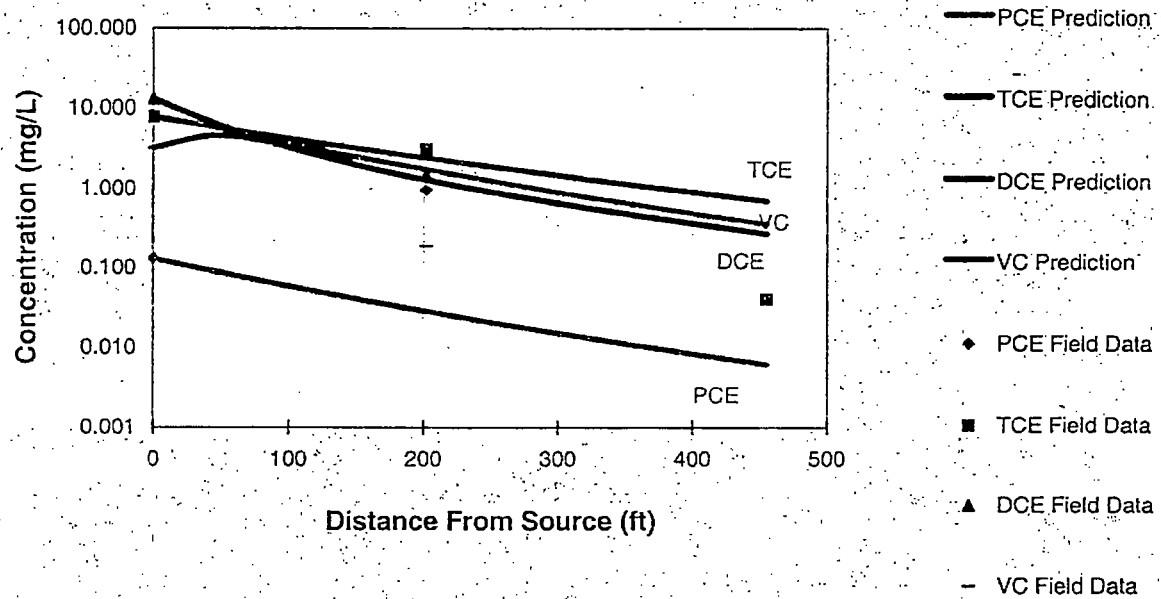


Figure 5-3. BIOCHLOR model, using assumed hydraulic conductivity of 8×10^{-4} .

Table 2-1
Summary of Groundwater Elevations, February 2002
USCG Old Base, St. Louis

WELL ID	TOC Elevation	Ground Surface Elevation	Total Depth	DTW 2/18/02	Elevation 2/18/02	DTW 2/20/02	Elevation 2/20/02	DTW 2/21/02	Elevation 2/21/02
MW-1	421.79	422.14	17.2	NM	NM	NM	NM	9.86	411.93
MW-4	421.51	421.81	24	NM	NM	NM	NM	8.06	413.45
MW-5	418.13	418.38	26.4	20.96	397.17	NM	NM	20.96	397.17
MW-6	417.48	418.43	26.6	21.48	396.00	NM	NM	21.48	396.00
MW-7	417.68	418.18	24.68	NM	NM	NM	NM	21.36	396.32
MW-8	418.41	418.71	22.43	20.56	397.85	20.56	397.85	NM	NM
MW-9	419.14	419.49	24.9	21.52	397.62	21.52	397.62	NM	NM
MW-10	419.38	419.68	19.24	14.24	405.14	14.24	NM	NM	NM
MW-11	419.07	---	30.14	18.42	400.65	18.42	NM	NM	NM

TOC = Top of Casing

NM = Not Measured

Monitoring Wells surveyed 2-28-02.

Wells surveyed relative to USGS Benchmark at 422.78 feet NGVD

Table 3-1
Summary of Remedial Investigation Soil Analytical Data
USCG Old Base, St. Louis
Page 1 of 6

Compound	Sample Identification Sample Date Units	CALM ⁶ STARC Scenario C	DP-2 15'-17' 2/19/02	DP-2 20'-22' 2/19/02	DP-2 25'-27' 2/19/02
VOLATILE ORGANIC COMPOUNDS ^a					
Acetone	ug/kg	8,700,000	344 U	7,010 U	3,590 U
Benzene	ug/kg	13,000	7.44 J	281	109 J
Bromobenzene	ug/kg	---	13.8 U	281 U	144 U
Bromochloromethane	ug/kg	---	13.8 U	281 U	144 U
Bromoform	ug/kg	---	13.8 U	281 U	144 U
Bromomethane	ug/kg	---	13.8 U	281 U	144 U
2-Butanone	ug/kg	---	344 U	7,010 U	3,590 U
n-Butylbenzene	ug/kg	---	13.8 U	156,000	144 U
sec-Butylbenzene	ug/kg	---	13.8 U	281 U	733
t-Butylbenzene	ug/kg	---	13.8 U	281 U	144 U
Carbon disulfide	ug/kg	721,000	13.8 U	281 U	144 U
Carbon tetrachloride	ug/kg	5,000	13.8 U	281 U	144 U
Chlorobenzene	ug/kg	180,000	37.9	25,000	948
Chloroethane	ug/kg	---	13.8 U	281 U	144 U
Chloroform	ug/kg	1,000	13.8 U	281 U	144 U
Chloromethane	ug/kg	---	13.8 U	281 U	144 U
2-Chlorotoluene	ug/kg	---	13.8 U	281 U	144 U
4-Chlorotoluene	ug/kg	---	13.8 U	281 U	144 U
1,2-Dibromo-3-chloropropane	ug/kg	5,000	68.9 U	1,400 U	718 U
Dibromochloromethane	ug/kg	77,000	13.8 U	281 U	144 U
1,2-Dibromoethane	ug/kg	---	13.8 U	281 U	144 U
Dibromomethane	ug/kg	---	13.8 U	281 U	144 U
1,2-Dichlorobenzene	ug/kg	600,000	13.8 U	281 U	144 U
1,3-Dichlorobenzene	ug/kg	---	13.8 U	281 U	144 U
1,4-Dichlorobenzene	ug/kg	51,000	13.8 U	4,400	144 U
Dichlorodifluoromethane	ug/kg	---	13.8 U	281 U	144 U
1,1-Dichloroethane	ug/kg	---	13.8 U	281 U	144 U
1,2-Dichloroethane	ug/kg	6,000	13.8 U	281 U	144 U
1,1-Dichloroethene	ug/kg	1,000	13.8 U	281 U	144 U
cis-1,2-Dichloroethene	ug/kg	1,200,000	13.8 U	281 U	144 U
trans-1,2-Dichloroethene	ug/kg	3,100,000	13.8 U	281 U	144 U
1,2-Dichloropropane	ug/kg	25,000	13.8 U	281 U	144 U
1,3-Dichloropropane	ug/kg	2,000	13.8 U	281 U	144 U
2,2-Dichloropropane	ug/kg	---	13.8 U	281 U	144 U
1,1-Dichloropropene	ug/kg	---	13.8 U	281 U	144 U
cis-1,3-Dichloropropene	ug/kg	---	13.8 U	281 U	144 U
trans-1,3-Dichloropropene	ug/kg	---	13.8 U	281 U	144 U
Ethylbenzene	ug/kg	400,000	38.6	88,100	4,420
Hexachlorobutadiene	ug/kg	46,000	13.8 U	281 U	144 U
2-Hexanone	ug/kg	---	68.9 U	1,400 U	718 U
Isopropylbenzene	ug/kg	210,000	16.5	38,700	2,210
4-Isopropyltoluene	ug/kg	---	13.8 U	10,100	144 U
4-Methyl-2-pentanone	ug/kg	---	68.9 U	1,400 U	718 U
Methylene chloride	ug/kg	150,000	34.4 U	701 U	359 U
Naphthalene	ug/kg	240,000	313	492,000	20,500
n-Propylbenzene	ug/kg	---	41.3	97,800	6,520
Styrene	ug/kg	1,500,000	13.8 U	281 U	144 U
1,1,1,2-Tetrachloroethane	ug/kg	24,000	13.8 U	281 U	144 U
1,1,2,2-Tetrachloroethane	ug/kg	5,000	13.8 U	281 U	144 U
Tetrachloroethene	ug/kg	120,000	13.8 U	5,500	460
Toluene	ug/kg	650,000	611	67,000	4,510
1,2,3-Trichlorobenzene	ug/kg	---	13.8 U	281 U	144 U
1,2,4-Trichlorobenzene	ug/kg	860,000	13.8 U	281 U	144 U
1,1,1-Trichloroethane	ug/kg	1,200,000	13.8 U	281 U	144 U
1,1,2-Trichloroethane	ug/kg	14,000	13.8 U	281 U	144 U
Trichloroethene	ug/kg	89,000	13.8 U	1,010	912

Table 3-1
Summary of Remedial Investigation Soil Analytical Data
USCG Old Base, St. Louis
Page 2 of 6

Compound	Sample Identification Sample Date Units	CALM ^a STARC Scenario C	DP-2 15'-17' 2/19/02	DP-2 20'-22' 2/19/02	DP-2 25'-27' 2/19/02
VOLATILE ORGANIC COMPOUNDS^a					
1,2,3-Trichloropropane	ug/kg	400	13.8 U	281 U	144 U
1,2,4-Trimethylbenzene	ug/kg	76,000	103	677,000	26,600
1,3,5-Trimethylbenzene	ug/kg	6,900,000	39.3	203,000	14,200
Vinyl chloride	ug/kg	600	13.8 U	281 U	144 U
Total Xylenes	ug/kg	418,000	145	610,000	32,300
Bromodichloromethane	ug/kg	41,000	13.8 U	281 U	144 U
Trichlorofluoromethane	ug/kg	1,400,000	13.8 U	281 U	144 U
TOTAL PETROLEUM HYDROCARBONS^b					
Gasoline Range Organics	ug/kg	---	6,890 U	2,050,000	205,000
Diesel Range Organics	ug/kg	---	47,700	1,350,000	207,000
TOTAL METALS^c					
Arsenic	mg/kg	14,000	8.17	47.2	10.2
Barium	mg/kg	51,000,000	327	212	280
Cadmium	mg/kg	380,000	1.36 U	2.55	1.37 U
Chromium	mg/kg	4,500,000	2.72	11	35.7
Lead	mg/kg	660,000	13.9	537	12.1
Mercury	mg/kg	1,000	0.138 U	0.14 U	0.139 U
Selenium	mg/kg	970,000	1.36 U	4.52	2.75
Silver	mg/kg	450,000	1.36 U	1.41 U	1.37 U
pH ^d			9.6	11.6	11.7

Notes:

a - Samples analyzed using SW-846 Method 8260B

b - Samples analyzed using SW-846 Method 8015B

c - Samples analyzed using SW-846 Method 6010B

d - Samples analyzed using SW-846 Method 9040

e - Cleanup Levels for Missouri (CALM), Tier I Soil Cleanup Standards, Scenario C, June 29, 2001.

Bolded Results are above the detection limit

--- Indicates no CALM standard is available

ug/kg = micrograms per kilogram

mg/kg = milligrams per kilogram

Qualifiers

U Compound not detected above method detection limit

J Estimated value

B Compound detected in method blank

Table 3-1.
Summary of Remedial Investigation Soil Analytical Data
USCG Old Base, St. Louis
Page 3 of 6

Compound	Sample Identification Sample Date Units	CALM ^c STAR C Scenario C	DP-3 5' -7' 2/20/02	DP-3 20'-22' 2/20/02	DP-3 25'-27' 2/20/02
VOLATILE ORGANIC COMPOUNDS^a					
Acetone	ug/kg	8,700,000	3,350 U	6,140 U	3,670 U
Benzene	ug/kg	13,000	134 U	246 U	147 U
Bromobenzene	ug/kg	---	134 U	246 U	147 U
Bromochloromethane	ug/kg	---	134 U	246 U	147 U
Bromoform	ug/kg	---	134 U	246 U	147 U
Bromomethane	ug/kg	---	134 U	246 U	147 U
2-Butanone	ug/kg	---	3,350 U	6,140 U	3,670 U
n-Butylbenzene	ug/kg	---	134 U	246 U	147 U
sec-Butylbenzene	ug/kg	---	134 U	12,400	293
t-Butylbenzene	ug/kg	---	134 U	246 U	147 U
Carbon disulfide	ug/kg	721,000	134 U	246 U	147 U
Carbon tetrachloride	ug/kg	5,000	134 U	246 U	147 U
Chlorobenzene	ug/kg	180,000	125 J	1,520	147 U
Chloroethane	ug/kg	---	134 U	246 U	147 U
Chloroform	ug/kg	1,000	134 U	246 U	147 U
Chloromethane	ug/kg	---	134 U	246 U	147 U
2-Chlorotoluene	ug/kg	---	134 U	246 U	147 U
4-Chlorotoluene	ug/kg	---	134 U	246 U	147 U
1,2-Dibromo-3-chloropropane	ug/kg	5,000	670 U	1,230 U	733 U
Dibromochloromethane	ug/kg	77,000	134 U	246 U	147 U
1,2-Dibromoethane	ug/kg	---	134 U	246 U	147 U
Dibromomethane	ug/kg	---	134 U	246 U	147 U
1,2-Dichlorobenzene	ug/kg	600,000	134 U	246 U	147 U
1,3-Dichlorobenzene	ug/kg	---	134 U	246 U	147 U
1,4-Dichlorobenzene	ug/kg	51,000	134 U	5,120	147 U
Dichlorodifluoromethane	ug/kg	---	134 U	246 U	147 U
1,1-Dichloroethane	ug/kg	---	130 J	246 U	147 U
1,2-Dichloroethane	ug/kg	6,000	134 U	246 U	147 U
1,1-Dichloroethene	ug/kg	1,000	134 U	246 U	147 U
cis-1,2-Dichloroethene	ug/kg	1,200,000	2,610	246 U	112 J
trans-1,2-Dichloroethene	ug/kg	3,100,000	161	246 U	147 U
1,2-Dichloropropane	ug/kg	25,000	134 U	246 U	147 U
1,3-Dichloropropane	ug/kg	2,000	134 U	246 U	147 U
2,2-Dichloropropane	ug/kg	---	134 U	246 U	147 U
1,1-Dichloropropene	ug/kg	---	134 U	246 U	147 U
cis-1,3-Dichloropropene	ug/kg	---	134 U	246 U	147 U
trans-1,3-Dichloropropene	ug/kg	---	134 U	246 U	147 U
Ethylbenzene	ug/kg	400,000	103 J	102,000	3,220
Hexachlorobutadiene	ug/kg	46,000	134 U	246 U	147 U
2-Hexanone	ug/kg	---	670 U	1,230 U	733 U
Isopropylbenzene	ug/kg	210,000	134 U	39,900	718
4-Isopropyltoluene	ug/kg	---	134 U	10,100	147 U
4-Methyl-2-pentanone	ug/kg	---	670 U	1,230 U	733 U
Methylene chloride	ug/kg	150,000	335 U	614 U	367 U
Naphthalene	ug/kg	240,000	503	369,000	7,700
n-Propylbenzene	ug/kg	---	134 U	90,500	1,720
Styrene	ug/kg	1,500,000	134 U	246 U	147 U
1,1,1,2-Tetrachloroethane	ug/kg	24,000	134 U	246 U	147 U
1,1,2,2-Tetrachloroethane	ug/kg	5,000	134 U	246 U	147 U
Tetrachloroethene	ug/kg	120,000	590	18,900	704
Toluene	ug/kg	650,000	442	65,100	3,310
1,2,3-Trichlorobenzene	ug/kg	---	134 U	246 U	147 U
1,2,4-Trichlorobenzene	ug/kg	860,000	134 U	246 U	147 U
1,1,1-Trichloroethane	ug/kg	1,200,000	630	246 U	147 U
1,1,2-Trichloroethane	ug/kg	14,000	134 U	246 U	147 U
Trichloroethene	ug/kg	89,000	84,500	2,130	293

Table 3-1
Summary of Remedial Investigation Soil Analytical Data
USCG Old Base, St. Louis
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Compound	Sample Identification Sample Date Units	CALM ^e STARC Scenario C	DP-3 5'-7' 2/20/02	DP-3 20'-22' 2/20/02	DP-3 25'-27' 2/20/02
VOLATILE ORGANIC COMPOUNDS ^a					
1,2,3-Trichloropropane	ug/kg	400	134 U	246 U	147 U
1,2,4-Trimethylbenzene	ug/kg	76,000	188	510,000	7,200
1,3,5-Trimethylbenzene	ug/kg	6,900,000	104 J	171,000	3,700
Vinyl chloride	ug/kg	600	134 U	246 U	147 U
Total Xylenes	ug/kg	418,000	442	658,000	23,000
Bromodichloromethane	ug/kg	41,000	134 U	246 U	147 U
Trichlorofluoromethane	ug/kg	1,400,000	134 U	246 U	147 U
TOTAL PETROLEUM HYDROCARBONS ^b					
Gasoline Range Organics	ug/kg	---	6,700 U	2,290,000	85,600
Diesel Range Organics	ug/kg	---	29,200	3,760,000	201,000
TOTAL METALS ^c					
Arsenic	mg/kg	14,000	64.2	4.88	2.6
Barium	mg/kg	51,000,000	247	216	151
Cadmium	mg/kg	380,000	23.6	1.22 B	1.44 U
Chromium	mg/kg	4,500,000	40.3	5.62	9.24
Lead	mg/kg	660,000	4060	6.59	47
Mercury	mg/kg	1,000	0.134 U	0.12 U	0.144 U
Selenium	mg/kg	970,000	13.3	3.42	2.02
Silver	mg/kg	450,000	1.33 U	1.22 U	1.44 U
pH ^d			6.2	11.8	12.2

Notes:

a - Samples analyzed using SW-846 Method 3260B

b - Samples analyzed using SW-846 Method 8015B

c - Samples analyzed using SW-846 Method 6010B

d - Samples analyzed using SW-846 Method 9040

e - Cleanup Levels for Missouri (CALM), Tier I Soil Cleanup Standards, Scenario C, Ju

Bolded Results are above the detection limit

--- Indicates no CALM standard is available

ug/kg = micrograms per kilogram

mg/kg = milligrams per kilogram

Qualifiers

U Compound not detected above method detection limit

J Estimated value

B Compound detected in method blank

Table 3-1
Summary of Remedial Investigation Soil Analytical Data
USCG Old Base, St. Louis
Page 5 of 6

Compound	Sample Identification Sample Date Units	CALM ^c STARC Scenario C	DP-4 2'-4' 2/20/02	DP-4 4'-6' 2/20/02	DP-4 6'-8' 2/20/02	DP-4 20'-22' 2/20/02
VOLATILE ORGANIC COMPOUNDS ^a						
Acetone	ug/kg	8,700,000	61 U	61.6 U	55.1 U	69 U
Benzene	ug/kg	13,000	2.04 J	1.47 U	3.3	3.31
Bromobenzene	ug/kg	---	2.44 U	2.46 U	2.2 U	2.76 U
Bromochloromethane	ug/kg	---	2.44 U	2.46 U	2.2 U	2.76 U
Bromoform	ug/kg	---	2.44 U	2.46 U	2.2 U	2.76 U
Bromomethane	ug/kg	---	2.44 U	2.46 U	2.2 U	2.76 U
2-Butanone	ug/kg	---	61 U	61.6 U	55.1 U	69 U
n-Butylbenzene	ug/kg	---	2.44 U	2.46 U	2.2 U	2.76 U
sec-Butylbenzene	ug/kg	---	2.44 U	2.46 U	2.2 U	2.76 U
t-Butylbenzene	ug/kg	---	2.44 U	2.46 U	2.2 U	2.76 U
Carbon disulfide	ug/kg	721,000	2.44 U	2.46 U	2.2 U	2.76 U
Carbon tetrachloride	ug/kg	5,000	2.44 U	2.46 U	2.2 U	2.76 U
Chlorobenzene	ug/kg	180,000	2.44 U	2.46 U	2.2 U	2.76 U
Chloroethane	ug/kg	---	2.44 U	2.46 U	2.2 U	2.76 U
Chloroform	ug/kg	1,000	2.44 U	2.46 U	2.2 U	2.76 U
Chloromethane	ug/kg	---	2.44 U	2.46 U	2.2 U	2.76 U
2-Chlorotoluene	ug/kg	---	2.44 U	2.46 U	2.2 U	2.76 U
4-Chlorotoluene	ug/kg	---	2.44 U	2.46 U	2.2 U	2.76 U
1,2-Dibromo-3-chloropropane	ug/kg	5,000	12.2 U	12.3 U	11 U	13.8 U
Dibromochloromethane	ug/kg	77,000	2.44 U	2.46 U	2.2 U	2.76 U
1,2-Dibromoethane	ug/kg	---	2.44 U	2.46 U	2.2 U	2.76 U
Dibromomethane	ug/kg	---	2.44 U	2.46 U	2.2 U	2.76 U
1,2-Dichlorobenzene	ug/kg	600,000	2.44 U	2.46 U	2.2 U	2.76 U
1,3-Dichlorobenzene	ug/kg	---	2.44 U	2.46 U	2.2 U	2.76 U
1,4-Dichlorobenzene	ug/kg	51,000	2.44 U	2.46 U	2.2 U	2.76 U
Dichlorodifluoromethane	ug/kg	---	2.44 U	2.46 U	2.2 U	2.76 U
1,1-Dichloroethane	ug/kg	---	2.44 U	2.46 U	2.2 U	2.76 U
1,2-Dichloroethane	ug/kg	6,000	2.44 U	2.46 U	2.2 U	2.76 U
1,1-Dichloroethene	ug/kg	1,000	2.44 U	2.46 U	2.2 U	2.76 U
cis-1,2-Dichloroethene	ug/kg	1,200,000	2.44 U	2.46 U	2.2 U	2.76 U
trans-1,2-Dichloroethene	ug/kg	3,100,000	2.44 U	2.46 U	2.2 U	2.76 U
1,2-Dichloropropane	ug/kg	25,000	2.44 U	2.46 U	2.2 U	2.76 U
1,3-Dichloropropane	ug/kg	2,000	2.44 U	2.46 U	2.2 U	2.76 U
2,2-Dichloropropane	ug/kg	---	2.44 U	2.46 U	2.2 U	2.76 U
1,1-Dichloropropene	ug/kg	---	2.44 U	2.46 U	2.2 U	2.76 U
cis-1,3-Dichloropropene	ug/kg	---	2.44 U	2.46 U	2.2 U	2.76 U
trans-1,3-Dichloropropene	ug/kg	---	2.44 U	2.46 U	2.2 U	2.76 U
Ethylbenzene	ug/kg	400,000	1.49 J	2.46 U	3.19	1.77 J
Hexachlorobutadiene	ug/kg	46,000	2.44 U	2.46 U	2.2 U	2.76 U
2-Hexanone	ug/kg	---	12.2 U	12.3 U	11 U	13.8 U
Isopropylbenzene	ug/kg	210,000	2.44 U	2.46 U	2.2 U	2.76 U
4-Isopropyltoluene	ug/kg	---	2.44 U	2.46 U	2.2 U	2.76 U
4-Methyl-2-pentanone	ug/kg	---	12.2 U	12.3 U	11 U	13.8 U
Methylene chloride	ug/kg	150,000	6.1 U	6.16 U	5.51 U	6.9 U
Naphthalene	ug/kg	240,000	6.1 U	6.16 U	5.51 U	6.9 U
n-Propylbenzene	ug/kg	---	2.44 U	2.46 U	2.2 U	2.76 U
Styrene	ug/kg	1,500,000	2.44 U	2.46 U	2.2 U	2.76 U
1,1,1,2-Tetrachloroethane	ug/kg	24,000	2.44 U	2.46 U	2.2 U	2.76 U
1,1,2,2-Tetrachloroethane	ug/kg	5,000	2.44 U	2.46 U	2.2 U	2.76 U
Tetrachloroethene	ug/kg	120,000	2.44 U	2.46 U	2.2 U	2.76 U
Toluene	ug/kg	650,000	5.24	3.33	8.92	7.86
1,2,3-Trichlorobenzene	ug/kg	---	2.44 U	2.46 U	2.2 U	2.76 U
1,2,4-Trichlorobenzene	ug/kg	860,000	2.44 U	2.46 U	2.2 U	2.76 U
1,1,1-Trichloroethane	ug/kg	1,200,000	2.44 U	2.46 U	2.2 U	2.76 U
1,1,2-Trichloroethane	ug/kg	14,000	2.44 U	2.46 U	2.2 U	2.76 U
Trichloroethene	ug/kg	89,000	2.44 U	2.46 U	18.4	2.76 U

Table 3-1
Summary of Remedial Investigation Soil Analytical Data
USCG Old Base, St. Louis
Page 6 of 6

Compound	Sample Identification Sample Date Units	CALM ^a STARC Scenario C	DP-4 2'-4' 2/20/02	DP-4 4'-6' 2/20/02	DP-4 6'-8' 2/20/02	DP-4 20'-22' 2/20/02
VOLATILE ORGANIC COMPOUNDS ^a						
1,2,3-Trichloropropane	ug/kg	400	2.44 U	2.46 U	2.2 U	2.76 U
1,2,4-Trimethylbenzene	ug/kg	76,000	1.82 J	2.46 U	4.19	2.41 J
1,3,5-Trimethylbenzene	ug/kg	6,900,000	2.44 U	2.46 U	3.08	2.76 U
Vinyl chloride	ug/kg	600	2.44 U	2.46 U	2.2 U	2.76 U
Total Xylenes	ug/kg	418,000	3.78	2.59	9.25	7.59
Bromodichloromethane	ug/kg	41,000	2.44 U	2.46 U	2.2 U	2.76 U
Trichlorofluoromethane	ug/kg	1,400,000	2.44 U	2.46 U	2.2 U	2.76 U
TOTAL PETROLEUM HYDROCARBONS ^b						
Gasoline Range Organics	ug/kg	---	6,100 U	6,160 U	5,510 U	6,900 U
Diesel Range Organics	ug/kg	---	12,100 U	18,800	11,000 U	13,700 U
TOTAL METALS ^c						
Arsenic	mg/kg	14,000	4.91	4.7	5.37	8.62
Barium	mg/kg	51,000,000	172	130	110	217
Cadmium	mg/kg	380,000	1.17 U	1.17 U	1.29	1.35 U
Chromium	mg/kg	4,500,000	22.2	18.6	27.9	20.5
Lead	mg/kg	660,000	6.54	8.93	134	9.7
Mercury	mg/kg	1,000	0.122 U	0.119 U	0.107 U	0.138 U
Selenium	mg/kg	970,000	1.17 U	1.17 U	2.79	1.35 U
Silver	mg/kg	450,000	1.17 U	1.17 U	1.07 U	1.35 U
pH ^d			8.9	8.6	8.9	8

Notes:

a - Samples analyzed using SW-846 Method 8260B

b - Samples analyzed using SW-846 Method 8015B

c - Samples analyzed using SW-846 Method 6010B

d - Samples analyzed using SW-846 Method 9040

e - Cleanup Levels for Missouri (CALM), Tier I Soil Cleanup Standards, Scenario C, Ju

Bolded Results are above the detection limit.

--- Indicates no CALM standard is available

ug/kg = micrograms per kilogram

mg/kg = milligrams per kilogram

Qualifiers

U Compound not detected above method detection limit

J Estimated value

B Compound detected in method blank

Table 3-2
Summary of Transformer Analytical Results
USCG Old Base
St. Louis, MO
Page 1 of 1

SERIAL NUMBER:	E-692937		
SAMPLE IDENTIFICATION:	XF332		
LAB NUMBER:	9912008915-001-01		
DATE COLLECTED:	2/21/02		
DATE ANALYZED:	3/1/02		
	ASTM #	*Limits	Results
NEUTRALIZATION NUMBER	D-974	0.2 max	0.038 mgKOH/g
COLOR	D-1500		0.5
DIELECTRIC	D-877	26 min	54 KV
INTERFACIAL TENSION	D-971	24 min	45.8 dynes/cm
VISUAL	D-1524		Pale Yellow, Clear. Sparkling
SPECIFIC GRAVITY			0.8898
WATER	D-1533	35 max;	10.0 ppm
PCB IN OIL (<2)	D-4059		87 ppm

Serial Number	E-692937	
Sample Identification	XF332	
Lab Number	9912008915-001-01	
Date Analyzed	2/26/02	
	IEEE Action Limit	2/21/02
Temperature		---
Oxygen		28832
Nitrogen		76122
Carbon Monoxide	580 ppm	323
Carbon Dioxide		5528
Hydrogen	240 ppm	52
Methane	160 ppm	409
Ethane	115 ppm	237
Ethylene	190 ppm	12
Acetylene	11 ppm	ND
Combustible Gases		942
Total Gas Content		111424

ND - Below Detection Limit

Bold results exceed Limit

*IEEE Guide for the determination of Generated Gases in Oil-Immersed Transformers their realltion to the Servicibility of the equipment. ANSI/IEEE C57.10

Table 3-3
Monitoring Well Survey Data
USCG Old Base St. Louis, MO

Station No.	BS.	F.S TOC	Ground	TOC Elevation	Ground Elevation
<i>Station 1 (West End)</i>					
B.M	4.41				422.78
MW1		5.40	5.05	421.79	422.14
MW4		5.68	5.38	421.51	421.81
MW11	long shot	8.12	7.82	419.07	419.37
<i>Station 2 (East End)</i>					
MW11	4.63 (TOC)			419.07	
MW10	long shot	4.32	4.02	419.38	419.68
MW8		5.29	4.99	418.41	418.71
MW9		4.56	4.21	419.14	419.49
MW5		5.57	5.32	418.13	418.38
MW6		6.22	5.27	417.48	418.43
MW7		6.02	5.52	417.68	418.18

US Coast Guard Benchmark Elevation 422.78 feet NGVD
Located at northwest corner of site.

Date of Survey 2/28/02

Table 4-1
Summary of Investigative-Derived Waste Analytical Results
USCG Old Base, St. Louis
Page 1 of 1

Compound	Sample Identification Sample Date Units	Soil Cuttings DP-4 2/21/02	Soil Cuttings DP-3 2/21/02	Soil Cuttings DP-1, DP-2 2/21/02
TCLP VOLATILE ORGANIC COMPOUNDS ^a				
Benzene	ug/L	20 U	20 U	20 U
Carbon tetrachloride	ug/L	20 U	20 U	20 U
Chlorobenzene	ug/L	20 U	20 U	50
Chloroform	ug/L	20 U	20	20
1,2-Dichloroethane	ug/L	20 U	20 U	20 U
1,1-Dichloroethene	ug/L	20 U	20 U	20 U
Methylethylketone	ug/L	100 U	100 U	230
Tetrachloroethene	ug/L	20 U	80	20 U
Trichloroethene	ug/L	20 U	40	80
Vinyl chloride	ug/L	20 U	20 U	20 U
TCLP SEMI-VOLATILE ORGANIC COMPOUNDS ^b				
Cresols	ug/L	10 U	10 U	10 U
1,4-Dichlorobenzene	ug/L	10 U	10 U	10 U
2,4-Dinitrotoluene	ug/L	10 U	10 U	10 U
Hexachlorobenzene	ug/L	10 U	10 U	10 U
Hexachlor-1,3-butadiene	ug/L	10 U	10 U	10 U
Hexachloroethane	ug/L	10 U	10 U	10 U
Nitrobenzene	ug/L	10 U	10 U	10 U
Pentachlorophenol	ug/L	10 U	10 U	10 U
Pyridine	ug/L	10 U	10 U	10 U
2,4,5-Trichlorophenol	ug/L	10 U	10 U	10 U
2,4,6-Trichlorophenol	ug/L	10 U	10 U	10 U
TCLP METALS ^c				
Arsenic	ug/L	100 U	100 U	100 U
Barium	ug/L	1000	1000 U	1000 U
Cadmium	ug/L	100 U	100 U	100 U
Chromium	ug/L	500 U	500 U	500 U
Lead	ug/L	500 U	500 U	500 U
Mercury	ug/L	10.0 U	10.0 U	10.0 U
Selenium	ug/L	100 U	100 U	100 U
Silver	ug/L	100 U	100 U	100 U

Notes:

a - Samples analyzed using SW-846 Method 8260B

b - Samples analyzed using SW-846 Method 8270C

c - Samples analyzed using SW-846 Method 6010B

Bolded Results are above the detection limit

ug/L = micrograms per liter

Qualifiers

U Compound not detected above method detection limit

Table 4-2
Summary of Analytical Results from
Phase II Monitoring Wells
USCG Old Base, St. Louis
Page 1 of 2

Sample Identification	Missouri Water	MW-1	MW-4	MW-5	MW-6	MW-7	MW-8	MW-9	MW-10	MW-11	MW-12
Sample Date	Quality	2/21/02	2/21/02	2/21/02	2/21/02	2/21/02	2/20/02 and 2/21/02	2/20/02	2/20/02	2/20/02	2/20/02
Compound	Units	Standards *									Duplicate of MW-10
VOLATILE ORGANIC COMPOUNDS *											
Chloromethane	ug/L	5	5.0 U	50.0 U	5.0 U	5.0 U	10.0 U	50.0 U	1.0 U	1.0 U	1.0 U
Vinyl chloride	ug/L	2	5.0 U	1,900	5.0 U	5.0 U	23.2	188	2.9	1.0 U	2.9
Bromomethane	ug/L	48	5.0 U	50.0 U	5.0 U	5.0 U	10.0 U	50.0 U	1.0 U	1.0 U	1.0 U
Chloroethane	ug/L		5.0 U	50.0 U	5.0 U	5.0 U	10.0 U	50.0 U	10.4	1.0 U	11.0
1,1-Dichloroethene	ug/L	7	5.0 U	50.0 U	5.0 U	5.0 U	10.0 U	50.0 U	1.0 U	1.0 U	1.0 U
Acetone	ug/L		50.0 U	500 U	50.0 U	227	115	10.0 U	4,580	10.0 U	10.0 U
Carbon disulfide	ug/L		5.0 U	50.0 U	5.0 U	5.0 U	10.0 U	50.0 U	1.0 U	1.0 U	1.0 U
Methylene chloride	ug/L	5	25.0 U	250 U	25.0 U	25.0 U	50.0 U	1,540	5.0 U	5.0 U	5.0 U
trans-1,2-Dichloroethene	ug/L	100	5.0 U	50.0 U	5.0 U	5.0 U	10.0 U	50.0 U	1.0 U	1.0 U	1.0 U
Methyl-t-butyl Ether	ug/L		10.0 U	100 U	10.0 U	10.0 U	20.0 U	100 U	2.0 U	2.0 U	2.0 U
1,1-Dichloroethane	ug/L		5.0 U	50.0 U	5.0 U	5.0 U	35.9	1,000	2.0	1.0 U	2.1
cis-1,2-Dichloroethene	ug/L	70	5.0 U	12,500	5.0 U	18.3	136	1.7	4,000	2.5	3.7
2-Butanone	ug/L		25.0 U	250 U	1070	1160	75.9	5.0 U	1,580	5.0 U	5.0 U
Chloroform	ug/L	100	5.0 U	50.0 U	5.0 U	5.0 U	10.0 U	1.0 U	50 U	1.0 U	1.0 U
1,1,1-Trichloroethane	ug/L	200	5.0 U	50.0 U	5.0 U	5.0 U	10.0 U	1.0 U	152	1.0 U	1.0 U
Carbon tetrachloride	ug/L	5	5.0 U	50.0 U	5.0 U	5.0 U	10.0 U	1.0 U	50 U	1.0 U	1.0 U
Benzene	ug/L	5	5.0 U	231	5.0 U	30.0	67.8	1.7	570	56.6	1.0 U
1,2-Dichloroethane	ug/L	5	5.0 U	50.0 U	5.0 U	5.0 U	10.0 U	1.0 U	50 U	1.0 U	1.0 U
Trichloroethene	ug/L	5	5.0 U	50.0 U	5.0 U	8.3	40.4	1.5	3,120	1.4	1.6
1,2-Dichloropropane	ug/L	100	5.0 U	50.0 U	5.0 U	5.0 U	10.0 U	1.0 U	50 U	1.0 U	1.0 U
Bromodichloromethane	ug/L	100	5.0 U	50.0 U	5.0 U	5.0 U	10.0 U	1.0 U	50 U	1.0 U	1.0 U
cis-1,3-Dichloropropene	ug/L	87	5.0 U	50.0 U	5.0 U	5.0 U	10.0 U	1.0 U	50 U	1.0 U	1.0 U
4-Methyl-2-pentanone	ug/L		25.0 U	250 U	25.0 U	25.0 U	50.0 U	5.0 U	250 U	5.0 U	5.0 U
Toluene	ug/L	1,000	5.0 U	5,750	219	476	882	1.0 U	15,400	1.0 U	1.0 U
trans-1,3-Dichloropropene	ug/L	87	5.0 U	50.0 U	5.0 U	5.0 U	10.0 U	1.0 U	50 U	1.0 U	1.0 U
1,1,2-Trichloroethane	ug/L	5	5.0 U	50.0 U	5.0 U	5.0 U	10.0 U	1.0 U	50 U	1.0 U	1.0 U
Tetrachloroethene	ug/L	5	5.0 U	50.0 U	5.0 U	5.0 U	10.0 U	1.0 U	968	1.0 U	1.0 U
2-Hexanone	ug/L		25.0 U	250 U	25.0 U	25.0 U	50.0 U	5.0 U	250 U	5.0 U	5.0 U
Dibromochloromethane	ug/L	100	5.0 U	50.0 U	5.0 U	5.0 U	10.0 U	1.0 U	50 U	1.0 U	1.0 U
Chlorobenzene	ug/L	100	5.0 U	89.5	5.0 U	17.3	151	3.0	196	30.7	1.0 U
Ethylbenzene	ug/L	700	5.0 U	812	5.0 U	58.4	308	1.0 U	2,780	1.0 U	1.0 U
Total Xylenes	ug/L	10,000	5.0 U	4,940	22.2	285	1,470	1.0 U	15,400	1.0 U	1.0 U
Bromoform	ug/L	100	5.0 U	50.0 U	5.0 U	5.0 U	10.0 U	1.0 U	50 U	1.0 U	1.0 U
1,1,2,2-Tetrachloroethane	ug/L	0.17	5.0 U	50.0 U	5.0 U	5.0 U	10.0 U	1.0 U	50 U	1.0 U	1.0 U
1,3-Dichlorobenzene	ug/L	600	5.0 U	50.0 U	5.0 U	5.0 U	10.0 U	1.0 U	50 U	1.0 U	1.0 U
1,4-Dichlorobenzene	ug/L	75	5.0 U	50.0 U	5.0 U	5.0 U	10.0 U	1.0 U	57.5	2.6	1.0 U
1,2-Dichlorobenzene	ug/L	600	5.0 U	50.0 U	5.0 U	8.4	40.6	1.8	846	21.8	1.0 U
Naphthalene	ug/L	20	5.0 U	5,320	11.4	38.3	307	2.0	1,570	1.0 U	1.0 U

Table 4-2
Summary of Analytical Results from
Phase II Monitoring Wells
USCG Old Base, St. Louis
Page 2 of 2

Compound	Sample Identification Sample Date Units	Missouri Water Quality Standards ^e	MW-1 2/21/02	MW-4 2/21/02	MW-5 2/21/02	MW-6 2/21/02	MW-7 2/21/02	MW-8 2/20/02 and 2/21/02	MW-9 2/20/02	MW-10 2/20/02	MW-11 2/20/02	MW-12 2/20/02 Duplicate of MW-10
CONVENTIONAL CHEMISTRY PARAMETERS^a												
Nitrogen, Total Kjeldahl	mg/L		0.38	0.95	3.68	3.38	2.51	2.25	7.48	1.54	0.43	1.19
Nitrogen, Ammonia	mg/L		0.21	0.35	3.52	3.52	2.49	2.16	4.95	1.71	0.46	1.80
Sulfide, Total	mg/L		0.10 U	0.25 U	3.6	10	14	0.10 U	24	6.0	0.10 U	5.2
Total Organic Carbon	mg/L		1.9	21.1	10.7	7.1	6.9	8.7	150	5.4	1.8	5.1
Alkalinity, as CaCO ₃	mg/L		439	519	269	182	187	172	3,760	302	330	310
DISSOLVED METALS^c												
Iron	mg/L		0.030 U	14.8	0.051	0.030 U	0.044	NA	0.324	0.030 U	0.288	0.030 U
Manganese	mg/L		2.49	9.89	0.025	0.010 U	0.010 U	NA	0.010 U	0.052	2.07	0.052
INORGANIC ANIONS^d												
Chloride	mg/L		22.2	164	100	283	68.3	54.4	260	118	175	116
Nitrogen, Nitrate+Nitrite	mg/L		0.4	0.2 U	0.3	0.3	0.2 U	0.5	1.0 U	0.2 U	5.6	2.3
Sulfate	mg/L		54.6	11.3	302	285	423	674	268	126	206	130
METABOLIC ACIDS^e												
Pyruvic Acid	mg/L		0.1 U	0.1 U	1.2	0.1 U	0.1 U	0.1 U	32.7	0.1 U	0.1 U	0.1 U
Lactic Acid	mg/L		1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	29.5	1.0 U	1.0 U	1.0 U
Acetic Acid	mg/L		1.0 U	34.3	1.0 U	1.0 U	1.0 U	1.0 U	6.4	1.0 U	1.0 U	1.0 U
Propionic Acid	mg/L		1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
Butyric Acid	mg/L		1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
PERMANENT GASES^f												
Ethylene	mg/L		0.010 U	0.160	0.014 U	0.010 U	0.010	0.020 U	0.021	0.010 U	0.008 U	0.010 U
Ethane	mg/L		0.010 U	0.590	0.014 U	0.010 U	0.010 U	0.056	0.008 U	0.065	0.008 U	0.068
Methane	mg/L		0.033	1.94	0.074	0.956	0.444	1.70	1.11	0.543	0.038	0.602
Carbon Dioxide	mg/L		18.0	16.9	0.028 U	0.020 U	0.020 U	0.097	0.016 U	0.221	7.43	0.210
TOTAL METALS^g												
Iron	mg/L		8.20	20.9	0.550	1.04	6.10	9.88	6.03	1.73	6.96	1.37
Manganese	mg/L		14.2	10.6	0.067	0.109	0.215	0.420	0.073	0.050	5.87	0.047
Phosphorus	mg/L		1.2	1.3	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U

Notes:

a - Samples analyzed using SW-846 Method 8260J

b - Samples analyzed using SM4500-N ORC, SM 4500-NH3, EPA 376.2, EPA 9060-SN1230 U

c - Samples analyzed using EPA 200.7

d - Samples analyzed using EPA 9056

e - Samples analyzed using HPLC/UV

f - Samples analyzed using ASTM D1945

g - Water Quality Standards from the Missouri 10 CSR 20-7.031

Bolded Results are above the Water Quality Standard

NA = Not Analyzed

ug/L = micrograms per liter

mg/L = milligrams per liter

Qualifies

U - Compound not detected above method detection limit

Table 4-3
Summary of Groundwater Analytical Results
from Remedial Investigation Temporary Wells
USCG Old Base, St. Louis
Page 1 of 2

Compound	Sample Identification Sample Date Units	Missouri Water Quality Standards ^d	DP-2 2/21/02	DP-3 2/21/02	DP-4 2/21/02
VOLATILE ORGANIC COMPOUNDS^a					
Acetone	ug/L		4,030	4,550	50 U
Benzene	ug/L	5	772	436	0.69 J
Bromobenzene	ug/L		10 U	10 U	1 U
Bromochloromethane	ug/L	90	10 U	10 U	1 U
Bromoform	ug/L	100	10 U	10 U	1 U
Bromomethane	ug/L	48	10 U	10 U	1 U
2-Butanone	ug/L		500 U	500 U	50 U
n-Butylbenzene	ug/L		10 U	10 U	1 U
sec-Butylbenzene	ug/L		10 U	75	1 U
t-Butylbenzene	ug/L		10 U	10 U	1 U
Carbon disulfide	ug/L		10 U	10 U	1 U
Carbon tetrachloride	ug/L	5	10 U	10 U	1 U
Chlorobenzene	ug/L	100	1,420	112	1.8
Chloroethane	ug/L		10 U	10 U	1 U
Chloroform	ug/L	100	10 U	10 U	1 U
Chloromethane	ug/L	5	10 U	10 U	1 U
2-Chlorotoluene	ug/L		10 U	10 U	1 U
4-Chlorotoluene	ug/L		10 U	10 U	1 U
1,2-Dibromo-3-chloropropane	ug/L		50 U	50 U	5 U
Dibromochloromethane	ug/L	100	10 U	10 U	1 U
1,2-Dibromoethane	ug/L		10 U	10 U	1 U
Dibromomethane	ug/L		10 U	10 U	1 U
1,2-Dichlorobenzene	ug/L	600	294	10 U	1 U
1,3-Dichlorobenzene	ug/L	600	10 U	10 U	1 U
1,4-Dichlorobenzene	ug/L	75	34	66	1 U
Dichlorodifluoromethane	ug/L		10 U	10 U	1 U
1,1-Dichloroethane	ug/L		163	442	2.7
1,2-Dichloroethane	ug/L	5	20	10 U	1 U
1,1-Dichloroethene	ug/L	7	10 U	10 U	1 U
cis-1,2-Dichloroethene	ug/L	70	842	2,100	16.4
trans-1,2-Dichloroethene	ug/L	100	10 U	10 U	1 U
1,2-Dichloropropane	ug/L	100	10 U	10 U	1 U
1,3-Dichloropropane	ug/L		10 U	10 U	1 U
2,2-Dichloropropane	ug/L		10 U	10 U	1 U
1,1-Dichloropropene	ug/L	87	10 U	10 U	1 U
cis-1,3-Dichloropropene	ug/L	87	10 U	10 U	1 U
trans-1,3-Dichloropropene	ug/L	87	10 U	10 U	1 U
Ethylbenzene	ug/L	700	2,220	3,960	4
Hexachlorobutadiene	ug/L	0.45	10 U	10 U	1 U
2-Hexanone	ug/L		100 U	100 U	10 U
Isopropylbenzene	ug/L		253	463	0.66 J
4-Isopropyltoluene	ug/L		10 U	10 U	1 U
4-Methyl-2-pentanone	ug/L		130	100 U	10 U
Methylene chloride	ug/L	5	20 U	66	2 U
Naphthalene	ug/L	20	3,220 B	4,480 B	15.1 B
n-Propylbenzene	ug/L		467	888	0.98 J
Styrene	ug/L	100	10 U	10 U	1 U
1,1,1,2-Tetrachloroethane	ug/L	70	10 U	10 U	1 U
1,1,2,2-Tetrachloroethane	ug/L	0.17	10 U	10 U	1 U

Table 4-3
Summary of Groundwater Analytical Results
from Remedial Investigation Temporary Wells
USCG Old Base, St. Louis
Page 2 of 2

Compound	Sample Identification Sample Date Units	Missouri Water Quality Standards ^a	DP-2 2/21/02	DP-3 2/21/02	DP-4 2/21/02
Tetrachloroethene	ug/L	5	168	1,080	1
Toluene	ug/L	1,000	12,400	15,400	8.9
1,2,3-Trichlorobenzene	ug/L		10 U	10 U	1 U
1,2,4-Trichlorobenzene	ug/L	70	10 U	10 U	1 U
1,1,1-Trichloroethane	ug/L	200	8.3	10 U	1 U
1,1,2-Trichloroethane	ug/L	5	10 U	10 U	1 U
Trichloroethene	ug/L	5	453	1,900	17.5
1,2,3-Trichloropropane	ug/L	40	10 U	10 U	1 U
1,2,4-Trimethylbenzene	ug/L		1,940	3,060	4.3
1,3,5-Trimethylbenzene	ug/L		976	1,650	2.6
Vinyl chloride	ug/L	2	10 U	50	7.6
Total Xylenes	ug/L	10,000	13,700	23,400	24
Bromodichloromethane	ug/L	100	10 U	10 U	1 U
Trichlorofluoromethane	ug/L		10 U	10 U	1 U
TOTAL PETROLEUM HYDROCARBONS ^b					
Gasoline Range Organics	ug/L		88,000	107,000	164
Diesel Range Organics	ug/L		18,200	106,000	160
TOTAL METALS ^c					
Arsenic	ug/L	50	174	180	104
Barium	ug/L	2,000	56.0	1710	2,140
Cadmium	ug/L	5	2.00	12.0	16.0
Chromium	ug/L	100	11.0	118	220
Lead	ug/L	15	28.0	642	1,260
Mercury	ug/L	2	0.400	1.10	3.20
Selenium	ug/L	50	9.00	52.0	30.0
Silver	ug/L	50	5.00 U	10.0 U	10.0 U

Notes:

a - Samples analyzed using SW-846 Method 8260B

b - Samples analyzed using SW-846 Method 8015B

c - Samples analyzed using SW-846 Method 6010B

d - Water Quality Standards from the Missouri 10 CSR 20-7.031; blank cells indicate no standard available

Results shown in bold are above the MWQS

ug/L = micrograms per liter

Qualifiers

U Compound not detected above method detection limit

J Estimated value

B Compound detected in method blank

Total Chlorinate VOCs	3,088	5,816	47
Total BTEX	29,092	43,196	38

Table 6-1
Potential Remedial Options for the USCG Site
Page 1 of 1

Remedial Option	Description	Advantages	Disadvantages
Source Area Remediation Technologies			
Treated Water Injection	Injection of air stripper effluent water to create flushing effect following removal of contaminants, particulates, and iron.	May enhance removal of some dissolved and lightly adsorbed VOC's through flushing action. Increased dissolved oxygen will help remove aerobically biodegradable contaminants.	Flushing could require lengthy period of time to be effective. Added dissolved oxygen could eliminate anaerobic mechanisms currently degrading highly chlorinated compounds. Uncertain permit requirements.
Amended Water Injection	Injection of air stripper effluent with oxygen source and/or inorganic nutrients added.	Increased dissolved oxygen will help remove aerobically biodegradable contaminants. If oxidant (peroxide or permanganate) is used, some chemical oxidation could take place catalyzed by iron in the groundwater. Inorganic nutrients could enhance biodegradation.	Increased oxygen from peroxide or permanganate could accelerate fouling of injection wells. Added dissolved oxygen could eliminate anaerobic mechanisms currently degrading highly chlorinated compounds. Uncertain permit requirements.
<i>in situ</i> chemical oxidation	Pressure injection of Fenton's reagent (hydrogen peroxide + ferrous sulfate) to create free radicals or permanganate which transform contaminants.	Rapid destruction of contaminants, even free product. Results can be achieved in typically two rounds of injection.	Increased groundwater temperatures could impact natural attenuation mechanisms. High pressure could cause uncontrolled reaction. Some processes require acidification of groundwater causing additional subsurface and handling issues.
Hydrogen Release Compound (HRC)	Injection of polylactate ester into the subsurface that hydrolyzes to release lactic acid and hydrogen fostering reductive dechlorination.	Slow release of hydrogen prompts efficient reductive dechlorination. No wells required for injection of the product. Can be most cost effective approach for chlorinated contaminant cleanup.	Cannot be used in the vadose zone. Required special pumping equipment for injection. Multiple injections may be necessary. Less effective on daughter products, cis-1,2 DCE and VC. An accumulation of cis-1,2 DCE and VC have occasionally been observed during treatment periods.
Plume Perimeter Remediation Technologies			
Barrier Wall	Emplacement of reactive media, such as iron filings, into a trench transecting the plume. Wall may be of limited length due to preferential flow through narrow sand seam.	Approach may effectively treat contaminants passing through the wall, thereby preventing migration. Media lifetime is permanent, given sufficient maintenance.	Cost of trench and media would be large if barrier through the sand and the clay downgradient of the site is required. Maintenance of the media (removal of scale) would probably be required, but would be manageable for a short length wall.
Biosparging in Wells	Injection of air into water-bearing zone to create air curtain and increase dissolved oxygen for biodegradation of vinyl chloride before it leaves the site.	Provides remediation of aerobically degradable VOC's (e.g., vinyl chloride) in groundwater where treatment can take place. Prevents off-site migration.	Sparged air will channel to certain extent and probably not feasible in low permeability zones. Anaerobically degradable contaminants would not be treated.
Air Sparging in Trench	Injection of air into water-bearing zone through trench configuration to create air curtain and increase dissolved oxygen for biodegradation of vinyl chloride before it leaves the site.	Provides remediation of aerobically degradable VOC's (e.g., vinyl chloride) in groundwater where treatment can take place. Prevents off-site migration. Trench application can be used through low permeability zones to cut off any VOC migration flow through these areas.	Sparged air will channel to certain extent and low permeability zones will not be remediated as quickly as high permeability zones. Anaerobically degradable contaminants would not be treated.
Air Sparging with SVE	Injection of air into water-bearing zone with vapor extraction of volatilized contaminants above water table.	Provides remediation of free product and volatiles in groundwater by volatilizing to vadose zone where contaminated vapors can be recovered with SVE system. Aerobic bioremediation in groundwater would also be accelerated by increasing dissolved oxygen content of groundwater.	Sparged air will channel to certain extent and low permeability zones will not be remediated as quickly as high permeability zones. System would require both injection and extraction systems and aboveground treatment of vapors may be required.
Oxygen Release Compound (ORC)	Addition of magnesium peroxide product to groundwater provides slow release of oxygen to water-bearing zone. Can be injected as a slurry or placed in wells in the form of filter socks.	Would help maintain aerobic biodegradation of cis-1,2 DCE and VC. Is gaining widespread application at VC sites in the U.S. and Canada.	Cost of ORC can be significant if more than two rounds of injection are required or more than three rounds of filter sock installation are required. ORC is most cost effective for areas without free product.

Appendix A

Phase II Environmental Evaluation Results

INTRODUCTION

The purpose of this project was to evaluate subsurface conditions at USCG Base St. Louis prior to the proposed construction of a new administration building. This work was authorized by Contracting Officer Ms. Pamela Komer after acceptance of our proposal dated December 12, 1991.

PROJECT BACKGROUND

A report prepared by ATEC Associates and dated March 19, 1991 identified soil contamination with volatile and semi-volatile organic compounds in the western portion of the base. Subsequent to the ATEC report, we completed a Phase I Environmental Evaluation as part of task order 02-1082. Items of potential environmental concern identified during the first phase of this project include two abandoned 8,000 gallon underground gasoline storage tanks located near the northwest corner of the base, a 500 gallon diesel underground tank in the northeast corner of the facility, and a former tank location under the present site of the EM Club. All of the tanks existing at the time of our Phase I report have since been removed.

An inventory was completed of the types of hazardous materials used, stored, and disposed of by the Coast Guard on-site. The information obtained during the Phase I study did not indicate that the operations of the Base have adversely affected the environmental quality of the site.

The primary item of environmental concern observed during our Phase I Evaluation was the presence of leachate seeping from the west bank of the Mississippi River just south of the boom dock. It was noted that the leachate had a chlorinated solvent odor, and a pH greater than 12. Base St. Louis is surrounded by industrial properties, and at the time of our Phase I study, it was suspected that the leachate may have originated from an off-site source.

A copy of the Phase I report is included as an appendix to this report.

PURPOSE

The purpose of this second phase of the evaluation was to characterize the subsurface conditions present at the base, and to begin to assess the type, extent, magnitude, and possible origin of the contamination identified during our initial evaluation, and previously by ATEC.

END(I)

WORKSCOPE

General Approach

This project included soil and groundwater sampling, analytical testing, interpretation and reporting.

Drilling Services

A total of 17 borings were drilled using a CME 55 truck mounted drill rig. Borings completed as monitor wells were drilled with 4-1/4 inch I.D. hollow stem augers. Field work was completed with level "D" personal protective clothing, and upgraded to level "C" gear for a short time at the discretion of the site safety officer.

Sampling tools, augers, and tooling were steam cleaned prior to starting work. The augers and tooling were steam cleaned between borings. Sampling tools were steam cleaned or cleaned with an ALCONOX detergent and water solution between samples. The samplers were then rinsed with tap water and deionized water prior to reuse.

Soil cuttings were placed in a roll-off container for storage and transport to a disposal facility. Water from decontamination was contained in a visqueen lined dike and then transferred to 55 gallon steel drums.

To determine if the site's soil and/or groundwater has been impacted by the identified potential sources of contamination, we completed seventeen borings. The approximate boring locations are shown on the attached Monitor Well and Boring Location Plan.

Borings near the underground storage tanks were drilled to 20 ft depths. Four borings were drilled to bedrock. The nine borings that were completed as wells were originally proposed to be drilled to a depth of 40 ft. A silt layer was encountered above the bedrock at an average depth of 25 ft. Therefore, some of the wells were completed at shallower depths because it was suspected that the silt would not yield sufficient water for testing samples.

Samples from the borings were obtained by Standard Penetration Test methods from the 2.0 to 4.0 ft, 5.0 to 7.0 ft, 8.0 to 10.0 ft, 13.0 to 15.0 ft, and 18.0 to 20.0 ft intervals using 24 inch long, 2 inch O.D. split-barrel samplers. Beyond the 20 ft depth the borings were sampled at 5 ft intervals.

An environmental geologist from our office was on-site during all

field work to direct the drillers, handle samples, and screen the samples using a photoionization detector (PID). The PID is used to check for indications of contamination with volatile organic compounds found in hydrocarbon fuels and solvents. Due to the caustic nature of the leachate along the river bank, samples were also tested with pH sensitive paper.

Monitor Well Construction, Development, and Sampling

The monitor wells were constructed of 2 inch diameter, flush joint threaded, schedule 40 Rigid PVC with 10 ft long 0.010 inch slotted screens. The wells were backfilled with clean silica sand to approximately 2 ft above the top of the screen. A 2 ft bentonite pellet plug was placed above the sand pack, and the remainder of the boring was backfilled with cement-bentonite grout to within 3 ft of the ground surface. A 6 inch diameter flush-mount manhole was used on all of the wells except for MW-1. The space between the grout and the protective manhole covers was filled with ready-mix concrete. A 5 inch I.D. steel protective riser with a locking cover was concreted in-place over the PVC riser at MW-1.

Groundwater, and top-of-casing elevations were measured at all wells to confirm the direction of groundwater flow across the site. Two USCG geodetic control points located at the northwest and southeast corners of the base were used to provide a reference datum. Ground surface elevations were taken from a site plan prepared by Miller, Stephenson, and Associates.

The wells were developed by bailing. The field work and reporting for this phase of the project was completed by an environmental geologist and an environmental technician. Well development consisted of surging a teflon bailer in the screened section of the monitor well. This was done to draw fine grained material in the filter pack through the screen, for removal. Surging continued until and turbidity was decreased. The USEPA does not approve of excessively turbid water samples, due to the possibility of adsorption/absorption effects interfering with the detection of low concentrations of volatile organic chemicals. The water removed from the wells during development was placed in 55 gallon drums which were labeled as to their point of origin.

Following development, the wells were sampled. The samples were handled, stored, and preserved, according to USEPA protocol. 8240 samples were preserved with hydrochloric acid, TRPH samples were preserved with sulfuric acid, and metals samples were preserved with nitric acid after field filtration. The metals samples were pressure filtered with lab grade dry nitrogen through a 0.45 micron membrane filter. The pressure filtration

apparatus is constructed of teflon coated 316 stainless steel. The apparatus was decontaminated and the filter changed between samples to prevent cross-contamination. All of the samples were kept as close to 4 degrees Centigrade as possible during transport to the laboratory, as required by USEPA protocol. Chain-of-Custody forms were used to document the sample custodians during collection, transport, and receipt at the laboratory.

Analytical Testing

Our budget included the analysis of seventeen soil samples, one from each boring. The samples were submitted for analysis for Total Recoverable Petroleum Hydrocarbons (TRPH) by Method 418.1, volatile organic compounds (VOC's) by Method 8240, pH, and total concentrations of TCLP listed metals. The samples were sent to BHM Laboratories of Chagrin Falls, Ohio and were chosen based on indications of contamination from the field PID screening and observations. In addition, the two samples with the greatest indication of contamination based on the TRPH analysis were tested for base-neutral and acid extractable semivolatile organic compounds by Method 8270. The soil samples tested for 8270 analytes were obtained from B-9 and B-16.

We had originally proposed to sample a monitor well which was thought to have been installed by ATEC Environmental Consultants in the western portion of the base at boring location E-6. We used the map scale in the ATEC report to locate Boring E-6 in the buoy pen area, where it was found that the boring was under a large number of spools of cable. We asked CWO2 Mike Dewey if it would be possible to move the cable in order to ascertain if a monitor well was indeed present at this location. Mr. Dewey referred us to MKC Gary Haley and BM1 Mark Helmers, who were present when the well was supposedly installed, and BMCS Bob Sanderson, who is in charge of the buoy storage area. The consensus of opinion of these three individuals was that ATEC never completed the boring as a well due to the fact that contamination was encountered, and they left the site quickly because they did not have any personal protective equipment. A review of the ATEC report, specifically the chain-of custody form at the end of the report, bears this conclusion out. Mr. Helmers further stated that he had seen the area in question when it was not covered with cable spools, and that to the best of his knowledge, no well was present.

Nine water samples were tested for TRPH, VOC's, pH, and TCLP listed metals. Four water samples from the wells showing the highest degree of TRPH contamination were also tested for 8270 analytes. The wells which were tested for 8270 analytes were MW-4, MW-5, MW-7, and MW-9.

Waste Testing and Disposal

We had estimated that about forty-nine 55 gallon drums of waste would be generated during field work. Due to the fact that bedrock was encountered at a shallower depth than anticipated, less waste soil was generated. In order to reduce cost, a roll-off box was brought to the site, and the soil cuttings were placed inside. We have made arrangements with Meiburger Environmental of St. Louis to dispose of the soil cuttings. Mr. Paul Meiburger has advised us that due to some problems with the analytical testing of the waste, it will be another two weeks before BFI will agree to dispose of the waste soil.

Decontamination water from the steam cleaning was placed in 55 gallon drums. The purge water from the development and sampling of the monitor wells was placed in individual drums, in order to segregate the waste streams, and potentially reduce disposal costs. We have made arrangements with Clayton Chemical Company of Sauget, Illinois to provide disposal services for the drummed water.

RESULTS

Subsurface Profile

The borings have revealed a subsurface profile consisting primarily of coarse granular fill overlying gray silt followed by limestone bedrock. The fill is composed of slag, gravel, bricks, paving stones, and foundry sand. Trace amounts of coal and glass were also noted in the fill. The fill thickness ranged from 0 to 32 ft at our borings, with depths increasing to the east toward the Mississippi River. Figure 1 is a graphic presentation of the fill thickness which was mapped using SURFER software.

Below the fill at an approximate depth of 25 ft is a layer of gray silt which was deposited in the floodplain of the Mississippi River. The silt thickness ranges from 5 to 10 ft, and overlies the St. Louis Limestone, the uppermost local bedrock unit. Copies of the Boring Logs are included in Appendix B.

Figure 2 is a contour map of the bedrock surface as identified by our borings. The bedrock is sloping down from northwest to southeast across the site. The bedrock ranges from an approximate elevation of 393.3 ft at the northwest corner of the site to 384.6 ft at the southeast corner of the site. Average depth to bedrock across the site is about 32 ft. There is a somewhat anomalous 2 ft depression in the bedrock surface in the north center of the site. The depression trends north to south, and

may represent an erosional surface.

Two geologic cross sections, and a section line location map are included in Appendix B with the boring logs. Cross section A to A' is from west to east, and section B to B' is oriented from north to south.

Field Observations and PID Screening

During the course of completion of our field work, several indications of environmental contamination were observed along the south and west boundaries of the base.

The PID readings obtained from the borings increased with depth, with the highest readings recorded from depth intervals ranging from 13 to 15 ft to the total depth of the borings. A PID reading of 175 parts per million was recorded from the 13 to 15 ft sample interval at B-4. We encountered a soil with strong creosote-like odor at B-4, and the soil retained by the augers had a heavy petroleum sheen on the surface.

A PID reading of 200 parts per million was obtained in the 18 to 20 ft sample from B-16. A solvent odor was also present. The highest PID reading recorded for any sample was 300 parts per million, from 18 ft to the total depth of B-9. This boring location had a strong smell of an aromatic or chlorinated solvent. Level "C" respiratory protection was used to complete B-9. The PID readings for all of the soil samples obtained from our test borings are presented on the boring logs in Appendix B.

Groundwater

A review of the survey results show that groundwater flow at Base St. Louis is in an easterly direction toward the Mississippi River. The water elevations at the monitor wells were measured to the nearest 0.01 ft, and the groundwater elevations between the wells were mapped using SURFER software. A SURFER map showing the estimated groundwater elevations for the site is included in Figure 3.

Bedrock is sloping to the southeast toward the Mississippi River, and groundwater is flowing through the fill placed above the silt overlying the bedrock. The silt and clay which overlies the bedrock along the flood plain of the river acts as a lower confining layer.

Results of Soil Analysis

Our review of the results of analytical testing for the soil

samples indicates that elevated concentrations of petroleum and chlorinated solvent based compounds are present in the soils from B-4, B-6, B-9, and B-16. These compounds include Benzene, 2-Butanone, Dichloroethene isomers, Dichlorobenzene isomers, Ethylbenzene, Tetrachloroethene, Toluene, and Xylene isomers. The concentration of 364 parts per million Xylene in the soil at B-9 is equivalent to .03% by weight. The volatile organic compounds detected in the samples from B-4 and B-9 appear to correspond well with those compounds previously detected in a sample analyzed by ATEC from their boring E-6. Some of these same chemicals are listed on a 1988 tank inventory sheet obtained from Chem Tech Industries by Lt. Rendon.

Selected organic contaminants which were detected in a majority of the soil samples obtained from the borings were contour mapped using SURFER software. These contour maps are presented in Appendix A. Toluene concentrations in soil are contour mapped in Figure 12, and Trichloroethene concentrations in the soil are presented in Figure 13. Other contaminants were not contour mapped because of insufficient data.

Contamination with volatile organic compounds was also detected in the soil samples from B-2, B-3, B-5, B-8, B-10, and B-17. Residual TRPH and BTEX concentrations were encountered at B-13, and B-15, which were completed at former underground storage tank locations.

The remainder of the samples collected from B-1, B-7, B-11, B-12, and B-14 did not indicate concentrations of VOC's above the limits of detection. A summary of the analytical results is presented on the following pages.

The results of the USEPA Method 8270 analysis indicated that the soil at B-9 is contaminated with Napthalene, Methylnapthalene, Dichlorobenzene isomers, and Phthalate Esters. Indications of contamination were also present in a sample tested from B-16, where concentrations of Napthalene and Phthalate Esters were detected. During the completion of our Phase I and II work it was noted that several railroad tank cars which were labeled as containing Napthalene were being loaded at Chem Tech Industries.

The results of the metals analysis indicate anomalous concentrations of mercury in most of the samples tested. Mercury is not thought to naturally occur in the soils derived from the limestone bedrock this far north of the Ozark Plateau, according to the MDNR publications "Geology and Ore Deposits of the St. Francois Mountains", and "Sediment Hosted Lead, Zinc and Barium deposits of the Midcontinent", which we reviewed during our Phase I evaluation. The mercury is likely to be a contaminant constit-

uent of the fill. Elevated lead concentrations above the mean of the rest of the samples tested were detected at B-13. B-13 was completed in the former underground gasoline tank location, and lead is a component of leaded gasoline.

TABLE I
RESULTS OF SOIL ANALYSIS
U.S. Coast Guard Base St. Louis
USEPA METHOD 8240
(Concentrations in Parts Per Million)

Boring/Monitor Well I.D.	B-1	B-2	B-3	B-4	B-5
Sample Depth Interval (ft.)	@13-15	@8-10	@2-4	@28-30	@23-25

COMPOUNDS DETECTED

BENZENE	ND	ND	ND	0.015	ND
2-BUTANONE	ND	ND	ND	ND	0.460
CHLOROBENZENE	ND	0.12	ND	ND	ND
CIS-1,2-DICHLOROETHENE	ND	ND	ND	0.850	ND
TRANS-1,2-DICHLOROETHENE	ND	ND	ND	0.140	ND
ETHYLBENZENE	ND	ND	ND	0.036	ND
TOLUENE	ND	0.028	0.012	0.054	0.022
TRICHLOROETHENE	ND	0.030	0.060	0.014	ND
VINYL CHLORIDE	ND	ND	ND	0.018	ND
TOTAL XYLENES	ND	ND	ND	0.062	0.008
1,2 DICHLOROBENZENE	ND	0.012	ND	ND	ND
1,4 DICHLOROBENZENE	ND	0.009	ND	ND	ND

	B-6	B-7	B-8	B-9	B-10
	@23-25	@18-20	@23-25	@18-20	@18-20
BENZENE	ND	ND	ND	ND	0.020
2-BUTANONE	0.410	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	0.008
CIS-1,2-DICHLOROETHENE	ND	ND	0.012	ND	0.013
TRANS-1,2-DICHLOROETHENE	ND	ND	ND	0.140	ND
ETHYLBENZENE	ND	ND	ND	60.8	ND
TETRACHLOROETHENE	ND	ND	ND	11.7	ND
TOLUENE	0.140	ND	ND	84.5	0.250

TABLE I (CONTINUED)

RESULTS OF SOIL ANALYSIS
 U.S. Coast Guard Base St. Louis
 USEPA METHOD 8240
 (Concentrations in Parts Per Million)

	B-6 @23-25	B-7 @18-20	B-8 @23-25	B-9 @18-20	B-10 @18-20
TRICHLOROETHENE	ND	ND	ND	3.2	0.010
TOTAL XYLENES	0.031	ND	ND	364	0.029
1,2 DICHLOROBENZENE	ND	ND	ND	13.9	0.007
1,4 DICHLOROBENZENE	ND	ND	ND	ND	ND

ND: Not Detected

Boring/Monitor Well I.D. Sample Depth Interval (ft.)	B-11 @23-25	B-12 @5-7	B-13 @5-7	B-14 @18-20	B-15 @8-10
BENZENE	ND	ND	ND	ND	ND
2-BUTANONE	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND
CIS-1,2-DICHLOROETHENE	ND	ND	ND	ND	ND
TRANS-1,2-DICHLOROETHENE	ND	ND	ND	ND	ND
ETHYLBENZENE	ND	ND	ND	ND	ND
TOLUENE	ND	ND	ND	ND	ND
TETRACHLOROETHENE	ND	ND	0.018	ND	ND
TRICHLOROETHENE	ND	ND	0.125	ND	0.020
VINYL CHLORIDE	ND	ND	ND	ND	ND
TOTAL XYLENES	ND	ND	ND	ND	0.031
1,2 DICHLOROBENZENE	ND	ND	ND	ND	ND
1,4 DICHLOROBENZENE	ND	ND	ND	ND	ND

Boring/Monitor Well I.D. Sample Depth Interval (ft.)	B-16 @18-20	B-17 @8-10
BENZENE	ND	0.113
2-BUTANONE	ND	ND
CHLOROBENZENE	ND	0.802
CIS-1,2-DICHLOROETHENE	ND	ND
TRANS-1,2-DICHLOROETHENE	ND	ND
ETHYLBENZENE	9.00	ND
TOLUENE	8.40	0.074
TETRACHLOROETHENE	2.10	ND
TRICHLOROETHENE	1.30	ND
VINYL CHLORIDE	ND	ND
TOTAL XYLENES	41.1	1.42
1,2 DICHLOROBENZENE	2.40	0.021
1,4 DICHLOROBENZENE	0.50	0.019

ND: Not Detected

TABLE II

RESULTS OF SOIL ANALYSIS
U.S. Coast Guard Base St. Louis
USEPA METHOD 8270
(Concentrations in Parts Per Million)

Boring/Monitor Well I.D.	B-9	B-16
Sample Depth Interval (ft.)	@18-20	@18-20

COMPOUNDS DETECTED

BIS(2-ETHYLHEXYL) PHTHALATE	ND	0.384
DI-N-BUTYL PHTHALATE	0.510	ND
1,2-DICHLOROBENZENE	2.060	ND
2-METHYLNAPHTHALENE	5.320	ND
NAPHTHALENE	12.39	1.045
PHENANTHRENE	0.310	ND

TABLE III

RESULTS OF SOILS ANALYSIS
U.S. Coast Guard Base St. Louis
USEPA METHOD 6010-TOTAL METALS
(Concentrations in Parts Per Million)

Boring/Monitor Well I.D.	B-1	B-2	B-3	B-4	B-5
Sample Depth Interval (ft.)	@13-15	@8-10	@2-4	@28-30	@23-25
ARSENIC	22.85	29.77	8.93	24.70	67.27
BARIUM	108.3	159.70	35.41	138.20	295.50
CADMIUM	<0.30	<0.30	<0.30	<0.30	<0.30
CHROMIUM	8.63	10.61	10.50	11.84	2.26
COPPER	15.17	12.06	34.97	15.67	4.39
LEAD	22.27	25.64	9.53	16.97	22.27
MERCURY	0.110	<0.10	<0.10	<0.09	<0.10
NICKEL	15.89	15.42	6.76	13.54	<0.60
SELENIUM	<1.50	<1.50	<1.50	<1.50	<1.50
SILVER	<0.30	<0.30	<0.30	<0.30	<0.30
ZINC	49.38	73.76	15.47	53.45	5.85

OTHER TESTING

Boring/Monitor Well I.D.	B-1	B-2	B-3	B-4	B-5
Sample Depth Interval (ft.)	@13-15	@8-10	@2-4	@28-30	@23-25
pH (METHOD 150.1)	6.94	8.62	8.47	8.18	10.51
TRPH (METHOD 418.1)	25.70	3.70	24.48	2.64	82.09

TABLE III (CONTINUED)

RESULTS OF SOIL ANALYSIS
U.S. Coast Guard Base St. Louis
USEPA METHOD 6010-TOTAL METALS
(Concentrations in Parts Per Million)

Boring/Monitor Well I.D.	B-6	B-7	B-8	B-9	B-10
Sample Depth Interval (ft.)	<u>@23-25</u>	<u>@18-20</u>	<u>@23-25</u>	<u>@18-20</u>	<u>@18-20</u>
ARSENIC	36.99	50.21	18.87	39.44	76.22
BARIUM	317.70	174.00	118.80	165.20	221.30
CADMIUM	<0.30	<0.30	<0.30	<0.30	<0.30
CHROMIUM	4.44	13.13	7.08	5.19	1.02
COPPER	7.01	26.96	7.59	5.89	2.68
LEAD	43.22	29.20	9.03	32.41	49.96
MERCURY	<0.10	<0.10	<0.100	<.120	<0.10
NICKEL	<0.60	14.26	9.19	6.09	1.57
SELENIUM	<1.50	<1.50	<1.50	<1.50	<1.50
SILVER	<0.30	<0.30	<0.30	<0.30	<0.30
ZINC	61.38	33.47	34.21	71.71	32.97

OTHER TESTING

Boring/Monitor Well I.D.	B-6	B-7	B-8	B-9	B-10
Sample Depth Interval (ft.)	<u>@23-25</u>	<u>@18-20</u>	<u>@23-25</u>	<u>@18-20</u>	<u>@18-20</u>
pH (METHOD 150.1)	10.12	10.36	9.20	10.47	9.85
TRPH (METHOD 418.1)	7.52	4.02	6.06	5,263	9.23

TABLE III (CONTINUED)

RESULTS OF SOIL ANALYSIS
U.S. Coast Guard Base St. Louis
USEPA METHOD 6010-TOTAL METALS
(Concentrations in Parts Per Million)

Boring/Monitor Well I.D.	B-11	B-12	B-13	B-14	B-15
Sample Depth Interval (ft.)	<u>@23-25</u>	<u>@5-7</u>	<u>@5-7</u>	<u>@18-20</u>	<u>@8-10</u>
ARSENIC	13.14	15.56	60.55	30.19	66.10
BARIUM	118.8	79.76	437.2	178.9	372.7
CADMIUM	<0.30	<0.30	0.85	<0.30	<0.30
CHROMIUM	6.51	8.05	18.10	6.18	9.25
COPPER	5.31	7.86	162.9	7.46	19.04
LEAD	9.48	25.42	294.9	12.35	59.04
MERCURY	0.110	0.092	0.388	0.203	0.169
NICKEL	8.10	7.07	23.47	8.22	4.64
SELENIUM	<1.50	<1.50	<1.50	<1.50	<1.50
SILVER	<0.30	<0.30	<0.30	<0.30	<0.30
ZINC	27.09	145.2	212.4	26.96	55.00

OTHER TESTING

Boring/Monitor Well I.D.	B-11	B-12	B-13	B-14	B-15
Sample Depth Interval (ft.)	<u>@23-25</u>	<u>@5-7</u>	<u>@5-7</u>	<u>@18-20</u>	<u>@8-10</u>
pH (METHOD 150.1)	8.26	8.50	8.16	9.20	9.27
TRPH (METHOD 418.1)	<1.00	66.23	23.31	<1.00	48.62

TABLE III (CONTINUED)

RESULTS OF SOIL ANALYSIS
U.S. Coast Guard Base St. Louis
USEPA METHOD 6010-TOTAL METALS
(Concentrations in Parts Per Million)

Boring/Monitor Well I.D.	B-16	B-17
Sample Depth Interval (ft.)	<u>@23-25</u>	<u>@5-7</u>

ARSENIC	37.81	24.79
BARIUM	138.2	178.3
CADMIUM	0.68	<0.30
CHROMIUM	7.29	8.31
COPPER	47.16	15.41
LEAD	99.92	57.89
MERCURY	0.633	0.225
NICKEL	9.26	11.17
SELENIUM	<1.50	<1.50
SILVER	<0.30	<0.30
ZINC	325.9	103.1

OTHER TESTING

Boring/Monitor Well I.D.	B-16	B-17
Sample Depth Interval (ft.)	<u>@23-25</u>	<u>@5-7</u>
pH (METHOD 150.1)	8.88	8.17
TRPH (METHOD 418.1)	101.6	11.11

Chemtech Tank Listing

The following is a August 19, 1991 tank inventory of Chemtech Industries, Inc. which was obtained at the request of Lt. Fred Sommer. The tank location numbers are referenced to a Chemtech Industries map. A copy of this map is at the Coast Guard Base in St. Louis. From our observations of the layout of the tank farm it appears that the largest capacity tanks (over 250,000 gallons) are located closest to the south boundary of the Coast Guard Base. We believe that the designation "LCS" means liquid caustic soda.

<u>TANK #</u>	<u>CAPACITY (GAL)</u>	<u>PRODUCT</u>
1	310,000	LCS 50% Reg. (Chemtech)
2	310,000	LCS 50% Reg. (Chemtech)
3	221,000	Acetone
4	420,000	Empty-Manway off
5	380,000	Shell Sol 140
6	380,000	LCS Regular
7	620,000	Toluene
8	620,000	LCS 50% Rayon (Monsanto)
9	210,000	Caustic Potash
10	20,000	Caustic Potash, Low Sodium
15	450,000	Mineral Spirits, Exempt
16	450,000	IPA 99%
22	50,000	Empty, Out of Service
23	50,000	Primary Amyl Acetate
24	50,000	Out of Service
25	50,000	Out of Service
27	815,000	Methanol
28	420,000	LCS 50% Rayon (Chemtech)
29	630,000	Xylene
30	450,000	LCS 50% Reg. (PPG)
31	30,000	Empty
32	30,000	V M & P (Texaco)
33	30,000	LPA Solvent
34	30,000	Ethyl Acetate 99%
35	30,000	Hill V M & P
36	20,000	NP Alcohol
37	20,000	Hill Heptane
38	20,000	Aromatic 150
39	20,000	Mineral Spirits, Exempt
40	20,000	SD3 Alcohol
41	20,000	Methyl Ethyl Ketone
42	20,000	Methyl Isobutyl Ketone
43	20,000	Shell Sol 140
44	20,000	B903 PreMix-B905
45	20,000	Aromatic 100

(Chemtech Tank Listing-Continued)

<u>TANK #</u>	<u>CAPACITY (GAL)</u>	<u>PRODUCT</u>
46	20,000	Form C Anhydrous
47	20,000	N Butyl Acetate
48	20,000	Heptane C
49	20,000	Chemsolv MPM (PM)
50	20,000	Base Oil 500
51	20,000	LPA Solvent
52	20,000	Empty
53	20,000	Mineral Spirits
54	20,000	Empty
55	11,600	MAK
56	20,000	N/P Acetate
57	20,350	Shell Sol 140 HT
58	12,000	Hexane B
59	12,000	Texanol
60	5,000	PM Acetate
61	10,000	Surfonic N 95
62	5,000	Surfonic N 95
63	12,000	DOPE
64	8,500	Blend Tank
65	15,000	B633-Midco Premix
66	20,000	Fuel Oil #2
67	20,000	Mineral Seal Oil
68	10,000	Amyl Acetate
69	5,000	Ethylene Glycol
70	5,000	F503 Contam w/Ethyl Ace.
71	5,000	Hexylene Glycol
72	8,000	Shell Sol 71 (odorless M.S.)
73	10,000	Diacetone
74	12,000	Chemsolv DB
75	8,000	Chemsolv EB
76	10,000	Empty
77	12,000	Methylene Chloride
78	8,000	Chemsolv EE Acetate
79	12,000	Chemsolv EEP
80	12,000	Normal Butyl Alcohol
81	7,884	Contam. Aromatic Mixture
82	5,000	EB Acetate
83	12,000	1,1,1 Triethane
84	8,000	Neodal (Tergitol)
85	15,000	Out of Service
86	11,200	Sulfuric Acid E Grade
87	4,000	Caustic Blend Tank
88	16,430	Muriatic Acid 20'
89	14,400	Muriatic Acid 20'
90	10,000	Nitric Acid 42'
91	8,400	P M P Gluconate
92	5,765	Phosphoric Acid 75% Tech

Groundwater Analysis Results

Groundwater samples were collected from each of the nine monitoring wells and submitted to BHM Laboratories for analysis of Volatile Organic Compounds by USEPA Method 8240, Total Concentrations of TCLP listed metals, and pH. Selected samples with the highest TRPH concentrations were also tested for USEPA Method 8270 analytes. Copies of the Analytical Laboratory Reports are included in Appendix D.

TABLE IV

RESULTS OF GROUNDWATER ANALYSIS
U.S. Coast Guard Base St. Louis
USEPA METHOD 8240
(Concentrations in Parts Per Million)

<u>COMPOUNDS DETECTED</u>	<u>MW-1</u>	<u>MW-4</u>	<u>MW-5</u>	<u>MW-6</u>	<u>MW-7</u>
ACETONE	ND	1.28	1.90	2.08	3.10
BENZENE	ND	0.50	0.029	0.039	0.153
2-BUTANONE	ND	ND	2.60	1.05	ND
CHLOROBENZENE	ND	0.030	0.802	ND	0.237
CHLOROMETHANE	.020	0.020	0.178	0.095	0.026
1,1-DICHLOROETHANE	ND	0.017	ND	0.022	0.113
CIS-1,2-DICHLOROETHENE	ND	13.2	ND	ND	0.519
TRANS-1,2-DICHLOROETHENE	ND	0.050	ND	ND	0.017
ETHYLBENZENE	ND	1.12	0.060	0.120	0.109
4-METHYL-2-PENTANONE	ND	ND	ND	0.037	ND
TOLUENE	ND	5.30	1.50	0.940	0.259
TRICHLOROETHENE	ND	ND	0.024	0.042	0.018
VINYL CHLORIDE	ND	1.10	ND	ND	0.144
TOTAL XYLENES	ND	5.38	0.360	0.652	0.352
1,2 DICHLOROBENZENE	ND	0.040	ND	0.024	0.013

ND: Not Detected

TABLE IV (CONTINUED)

RESULTS OF GROUNDWATER ANALYSIS
 U.S. Coast Guard Base St. Louis
 USEPA METHOD 8240
 (Concentrations in Parts Per Million)

Monitor Well I.D.	<u>MW-8</u>	<u>MW-9</u>	<u>MW-10</u>	<u>MW-11</u>
<u>COMPOUNDS DETECTED</u>				
ACETONE	0.276	20.5	ND	ND
BENZENE	0.018	0.278	0.092	ND
CHLOROBENZENE	ND	ND	0.032	ND
CHLOROETHANE	ND	ND	0.048	ND
CHLOROMETHANE	0.009	ND	ND	0.055
1,1-DICHLOROETHANE	0.040	0.284	0.150	ND
CIS-1,2-DICHLOROETHENE	0.124	2.58	0.047	ND
ETHYLBENZENE	0.027	1.20	0.005	ND
4-METHYL-2-PENTANONE	0.040	1.41	ND	ND
TETRACHLOROETHENE	ND	0.367	0.010	0.014
TOLUENE	0.118	4.28	0.020	ND
1,1,1-TRICHLOROETHANE	ND	ND	0.022	ND
TRICHLOROETHENE	0.023	0.974	0.128	ND
VINYL CHLORIDE	0.067	ND	ND	ND
TOTAL XYLENES	ND	1.804	0.016	ND
1,2 DICHLOROBENZENE	ND	0.235	0.006	ND

ND: Not Detected

TABLE V

RESULTS OF GROUNDWATER ANALYSIS
 U.S. Coast Guard Base St. Louis
 USEPA METHOD 6010-TOTAL METALS
 (Concentrations in Parts Per Million)

Monitor Well I.D.	<u>MW-1</u>	<u>MW-4</u>	<u>MW-5</u>	<u>MW-6</u>	<u>MW-7</u>
ARSENIC	<0.01	<0.04	<0.01	0.10	<0.04
BARIUM	0.08	0.09	0.06	<0.01	<0.01
CADMIUM	<0.01	<0.01	<0.01	<0.01	<0.01
CHROMIUM	<0.01	<0.01	0.03	<0.01	<0.01
COPPER	<0.01	<0.01	<0.01	<0.01	<0.01
LEAD	<0.03	<0.03	<0.03	<0.03	<0.03
MERCURY	<0.0002	0.0052	<0.0002	<0.0002	<0.0002
NICKEL	<0.02	0.02	<0.02	<0.02	<0.02
SELENIUM	0.14	<0.01	<0.05	0.30	0.19
SILVER	<0.01	<0.01	<0.01	<0.01	<0.01
ZINC	<0.01	<0.01	<0.01	<0.01	<0.01

 OTHER TESTING

Monitor Well I.D.	<u>MW-1</u>	<u>MW-4</u>	<u>MW-5</u>	<u>MW-6</u>	<u>MW-7</u>
pH (METHOD 150.1)	6.63	6.73	11.90	11.68	9.77
TRPH (METHOD 418.1)	2.30	6.32	3.13	2.50	11.55

TABLE V (CONTINUED)

RESULTS OF GROUNDWATER ANALYSIS
 U.S. Coast Guard Base St. Louis
 USEPA METHOD 6010-TOTAL METALS
 (Concentrations in Parts Per Million)

Monitor Well I.D.	<u>MW-8</u>	<u>MW-9</u>	<u>MW-10</u>	<u>MW-11</u>
ARSENIC	<0.04	0.11	<0.04	<0.04
BARIUM	<0.01	<0.01	<0.01	<0.01
CADMIUM	<0.01	<0.01	<0.01	<0.01
CHROMIUM	<0.01	<0.01	<0.01	<0.01
COPPER	<0.01	<0.01	<0.01	<0.01
LEAD	<0.03	<0.03	<0.03	<0.03
MERCURY	<0.0002	<0.0002	<0.0002	<0.0002
NICKEL	<0.02	<0.02	<0.02	<0.02
SELENIUM	<0.05	0.16	0.14	0.11
SILVER	<0.01	<0.01	<0.01	<0.01
ZINC	<0.01	<0.01	<0.01	<0.01

OTHER TESTING

Monitor Well I.D.	<u>MW-8</u>	<u>MW-9</u>	<u>MW-10</u>	<u>MW-11</u>
pH (METHOD 150.1)	9.08	11.71	9.36	6.77
TRPH (METHOD 418.1)	3.31	71.05	4.66	2.05

TABLE VI

RESULTS OF GROUNDWATER ANALYSIS
 U.S. Coast Guard Base St. Louis
 USEPA METHOD 8270
 (Concentrations in Parts Per Million)

Monitor Well I.D.	<u>MW-4</u>	<u>MW-5</u>	<u>MW-7</u>	<u>MW-9</u>
<u>COMPOUNDS DETECTED</u>				
ACENAPTHENE	0.196	ND	ND	ND
BENZO(A)ANTHRACENE	0.028	ND	ND	ND
BIS(2-ETHYLHEXYL) PHTALATE	ND	ND	ND	0.147
CHRYSENE	0.024	ND	ND	ND
DIBENZOFURAN	0.184	ND	ND	ND
1,2-DICHLOROBENZENE	ND	ND	ND	0.092
FLUORANTHENE	0.160	ND	ND	ND
FLUORENE	0.232	ND	ND	2.60
NAPTHALENE	0.638	ND	0.016	0.540
2-METHYLNAPTHALENE	ND	ND	ND	0.076
PHENANTHRENE	0.272	ND	ND	ND
PYRENE	0.068	ND	ND	ND
2,4-DIMETHYLPHENOL	0.078	ND	ND	ND

ND: Not Detected

INTERPRETATION

Maximum Contaminant Levels (MCLs) have been established or are proposed (PMCLs) for contaminants in drinking water supplies for some of the chemical compounds and metals identified in this study. These MCLs are part of the Safe Drinking Water Act, and are enforceable.

The USEPA has issued a draft document entitled "Guidance in Developing Health Criteria for Determining Unreasonable Risk to Health", which presents contaminant levels considered to pose "unreasonable risk to health (URTH)" for drinking water supplies. This document states that the URTH values, and methods for calculating the values, are to be used only as guidelines, and are not actually regulatory levels enforceable by law. The document has been published to assist states in issuing variances or exemptions from Maximum Contaminant Levels established by Federal law.

Because the proposed URTH values apply to drinking water supplies, it seems reasonable to assume that contaminant levels in soil below the URTH, and in an area where the groundwater is not likely to be used as a drinking water source, may not require remediation.

In addition to these regulatory levels and guidelines, the USEPA has published proposed action levels for contaminants in soil and water in 55 CFR 30798 to 30834. Again, these are proposed levels as of July 27, 1990, and would probably be used only as guidelines by a regulatory agency.

To provide a visual aid to understanding the approximate extent of the contaminant plumes, pH and chemical contaminant concentrations were contour mapped using SURFER software. Figure 4 is a isopach map of the pH values for water samples obtained from the 9 monitor wells. Other isoconcentration maps for water contaminants are presented in Appendix A and include: Benzene (Figure 5), Toluene (Figure 6), Ethylbenzene (Figure 7), Xylene (Figure 8), Acetone (Figure 9), Cis-1,2-Dichloroethene (Figure 10), and Trichloroethene (Figure 11).

Benzene was detected in the groundwater in seven of the nine monitor wells, at concentrations above the water action level. Benzene has a solubility in water of 0.18%. Benzene is a known carcinogen, with a low MCL of .005 parts per million. Benzene was detected in all wells except MW-1 and MW-11. Toluene, Ethylbenzene, and Xylene are similar aromatic hydrocarbons to benzene.

These compounds are all lighter than water. This family of hydrocarbons is commonly referred to as BTEX. Toluene has a solubility in water of 0.05%, Ethylbenzene 0.015%, and Xylene 0.00003%. The isoconcentration maps show that Benzene (Figure 5), Toluene (Figure 6), Ethylbenzene (Figure 7), and Xylene (Figure 8) are apparently entering the site from two separate sources to the south of MW-4 and MW-9. Refer to Table IV for Toluene, Ethylbenzene, and Xylene contaminant concentrations detected in the water samples, and the relevant "Regulatory" levels in Table VII.

Acetone was detected in 6 of the nine wells and was detected at a concentration above the water action level in a sample from MW-9 (Figure 9). Acetone is soluble in water in all proportions. The water action levels are USEPA guidelines and are not law. The SURFER plot of Acetone concentrations in the groundwater illustrates the magnitude of the increasing contaminant levels to the south, at MW-9.

Mercury was detected at a concentration above the water action level in a sample from MW-4 only. Vinyl Chloride, a chemical for which the USEPA has a low maximum contaminant level goal of 0.002 parts per million, is present at a concentration of 1.1 parts per million at MW-4, and at no other well locations. It is likely that Vinyl Chloride and Mercury would be detected in additional monitor wells placed along the railroad tracks to the west of the base.

Other chlorinated hydrocarbons, in the form of Dichloroethene isomers (Figure 10), and Trichloroethene (Figure 11) are present above their MCLs in most of the samples collected from the monitor wells. These types of chlorinated hydrocarbons are heavier than water and sink. Trichloroethene has a solubility in water of 0.1%. During the completion of our test borings it was observed that the uppermost foot of the gray silt often had a chlorinated solvent type of odor. This odor was absent or not as noticeable in the samples obtained from the overlying fill.

Dichlorobenzene isomers, are present in the groundwater at concentrations below action levels for water. There is no MCL data available for Naphthalene and Methylnaphthalene, which were also detected in some of the water samples.

Table VII on the following page presents USEPA data on MCLs, URTH concentrations in groundwater, and proposed action levels for the organic and inorganic contaminants identified in the soil and/or groundwater at USCG Base St. Louis.

Because the highest levels of most contaminants were detected in

MW-4 and MW-9, the two closest wells to the Chem-Tech property, it seems reasonable to conclude that the soil and groundwater contamination may originate on the Chem-Tech site. The SURFER plots of contaminant isoconcentrations give additional evidence of the estimated magnitude of the problem.

Additional borings and monitor wells would help to better determine the extent of contamination along the south and west portions of the base.

TABLE VII
"REGULATORY" LEVELS FOR CONTAMINANTS
IDENTIFIED AT BASE ST. LOUIS
(Concentrations in Parts Per Million)

<u>CONTAMINANT</u>	<u>MCL or PMCL</u>	<u>Recommended URTH Level</u>	<u>Soil Action Level</u>	<u>Water Action Level</u>
Acetone	NA	NA	8,000	4.0
Acenapthene	NA	NA	NA	NA
2-Butanone	NA	NA	NA	NA
Benzo(a)- -Anthracene	NA	NA	NA	NA
Benzene	.005	0.01	NA	.005
Chlorobenzene	NA	NA	2,000	70
Chrysene	NA	NA	NA	NA
Dibenzofuran	NA	NA	NA	NA
1,1 Dichloro- -ethane	NA	NA	NA	NA
1,2 Dichloro- -benzene	NA	NA	NA	NA
Cis-1,2 Di- -chloroethene	0.07	0.4	NA	NA
Trans-1,2 Di- -chloroethene	0.1	2.0	NA	NA
2,4-Dimethyl- -phenol	NA	NA	NA	NA
Ethylbenzene	0.7	1.0	3,000	4.0
Fluoranthene	NA	NA	NA	NA
Fluorene	NA	NA	NA	NA
4-Methyl-2- -Pentanone	NA	NA	NA	NA
Mercury	0.002	0.01	20	0.004

TABLE VII (Continued)

"REGULATORY" LEVELS FOR CONTAMINANTS
IDENTIFIED AT BASE ST. LOUIS
(Concentrations in Parts Per Million)

<u>CONTAMINANT</u>	<u>MCL or PMCL</u>	<u>Recommended URTH Level</u>	<u>Soil Action Level</u>	<u>Water Action Level</u>
Napthalene	NA	NA	NA	NA
Phenanthrene	NA	NA	NA	NA
Pyrene	NA	NA	NA	NA
Tetrachloroethene	NA	NA	NA	NA
Toluene	2.0	NA	20,000	10
Trichloroethene	0.002	0.002	60	1.0
Total Xylenes	10	40	200,000	70
Vinyl Chloride	0.0	0.002	NA	NA

The applicable maximum contaminant levels or proposed maximum contaminant levels (MCL/PMCL's) are taken from the Federal Safe Drinking Water Act of 1974, and its subsequent amendments. The soil and water action levels are taken from The Code of Federal Regulations CFR Section 264.521(a)(2)(i-iv) "Appendix A.-Examples of Concentrations Meeting Criteria for Action Levels". The URTH levels are from an October 1990 USEPA Office of Drinking Water draft document entitled "Guidance in Developing Health Criteria for Determining Unreasonable Risks to Health."

CONCLUSIONS

The results of chemical analysis of the soils obtained from test borings completed in the former underground storage tank locations indicates that the soils do not contain concentrations of BTEX which are likely to require further remediation. We have recently reviewed information from MDNR which indicates that no further cleanup is required, according to the "Missouri Corrective Action Guidance Document, Table 3".

The potential sources of contamination identified at the site include previous usage by the Mississippi Valley Iron Company. The fill at the site could contain hazardous constituents, and may be affecting the pH of the water. There is sufficient evidence to suspect that a spill or series of spills may have occurred at the tank car transfer point located to the west of the southwest corner of the site. There is a possibility that leakage has occurred at points along the Chem-Tech above ground transfer pipeline located just to the south of the base. Another potential source of contamination is the above ground storage tanks at Chem-Tech. In consideration of the information and data obtained to date, the likeliest source of volatile organic con-

tamination is the Chem-Tech Industries property.

Many of the organic chemicals detected in the soil samples are only slightly soluble in water. The isoconcentration contours of many of the less soluble organic chemicals increase to the south towards the Chem-Tech property. These chemicals are likely to persist in the groundwater for a long time until the source of contamination is removed. The fill underlying the site is porous and is underlain by a relatively impermeable silt layer encountered at an average depth of 25 ft.

RECOMMENDATIONS

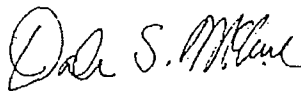
Any remediation effort involving extraction wells should take into account the porous nature of the fill which is likely to extend onto adjacent sites. Attempts to remove the contaminated groundwater by flushing the site may not be effective considering the probable scale of the problem to the south and possibly west of Base-St. Louis.

To obtain useful data, any further exploration should extend off-site to the south and west. Depending on input from your legal counsel, you may need to inform MDNR of the results of groundwater monitoring since the concentrations of acetone, benzene, mercury, and chlorinated solvents exceed water action levels. Efforts should be continued to attempt to confirm the sources of the contamination. Once the source and full extent of contamination is identified, a suitable remediation technology may be selected.

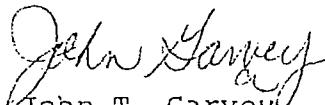
The conclusions and recommendations presented in this report are based on available data and may be revised as additional data is obtained. This report is not to be considered legal advice but rather a summary of existing geoenvironmental conditions at Base-St Louis. If you have any questions or comments regarding this report, please do not hesitate to call us.

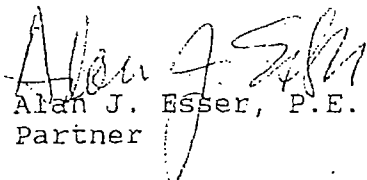
SIGNATURES

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LABORATORY LOG OF BORING NUMBER: B-1					PROJECT: USCG Base St. Louis					
CLIENT: United States Coast Guard					BORING DEPTH: 28.5 ft					
LOCATION: Foot of Iron Street, St. Louis Mo.					BORING DATE: January 27, 1992					
DRILLING METHOD: Hollow stem auger					ENCOUNTERED WATER: 17 ft.					
SURFACE ELEVATION:					WATER ON COMPLETION: N/A					
D E P T H (ft)	S A M P L E	T Y P E	S Y M B O L	SOIL DESCRIPTION	STANDARD PEN. blows/6in.	PID RESULT (ppm)	DRY UNIT WEIGHT (pcf)	PL (%)	WC (%)	LL (%)
				Topsoil (12")						
1				FILL: Gravel and blue slag	14-20-11-9	0				
5				FILL: Brown silty clay with fine sand	3-4-3-4	0				
10				FILL: Gray silt with gravel	2-5-2-4	18				
15				Stiff brown lean CLAY with gray silt seams, creosote odor (CL)	2-5-6-6	35				
20					2-2-2-2	0				
25				Loose brown SILT with clay (ML)	3-2-2-3	0				
30				Loose brown fine SAND (SP)	9-50/3"					
				Weathered LIMESTONE bedrock						
				Auger Refusal at 28.5 ft						
35										
40										

LABORATORY LOG OF BORING NUMBER: B-2					PROJECT: USCG Base St. Louis					
CLIENT: United States Coast Guard					BORING DEPTH: 31.5 ft					
LOCATION: Foot of Iron Street, St. Louis Mo.					BORING DATE: January 21, 1992					
DRILLING METHOD: Hollow stem auger					ENCOUNTERED WATER: 7.5 ft, 17 ft					
SURFACE ELEVATION:					WATER ON COMPLETION: N/A					
D E P T H (ft)	S A M P L E	T Y P E	S Y M B O L	SOIL DESCRIPTION	STANDARD PEN. blows/6in.	PID RESULT (ppm)	DRY UNIT WEIGHT (pcf)	PL (%)	WC (%)	LL (%)
				FILL: Gravel (12")						
1				FILL: Black oil stained sand with slag	9-6-2-1	0				
5				FILL: Slag and gravel	1-7-8-3	14				
3				Medium dense gray SILT with black staining (ML)	5-8-8-4	0				
10										
4				Stiff brown lean CLAY with gray silt seams (CL)	3-5-6-8	0				
15										
5				Soft gray lean CLAY with gray silt seams (CL)	2-2-2-4	0				
20										
6				Medium gray lean CLAY with sand (CL)	2-3-3-4	0				
25										
7				Loose brown fine SAND with organics (SP)	8-9-3-2	0				
30										
8				Hard LIMESTONE	50/0	0				
35										
				Auger Refusal at 31.5 ft						
40										

LABORATORY LOG OF BORING NUMBER: B-3					PROJECT: USCG Base St. Louis					
CLIENT: United States Coast Guard					BORING DEPTH: 32.8 ft					
LOCATION: Foot of Iron Street, St. Louis Mo.					BORING DATE: January 21, 1992					
DRILLING METHOD: Hollow stem auger					ENCOUNTERED WATER: 17 ft					
SURFACE ELEVATION:					WATER ON COMPLETION: N/A					
					WATER AFTER HRS.: N/A					
D E P T H (ft)	S A M P L E	T Y P E	S Y N T H E T I C	SOIL DESCRIPTION	STANDARD PEN. blows/6in.	PID RESULT (ppm)	DRY UNIT WEIGHT (pcf)	PL (%)	WC (%)	LL (%)
1				1" Asphalt, 3" Concrete						
5				FILL: Sand with slag stained black	6-6-7-23	0				
2				FILL: Slag and gravel	6-9-11-12	0				
3					9-3-2-4	0				
10										
4				FILL: Slag, sand, and clay	6-11-10-5	0				
15										
5				Loose gray SILT (HL)	5-3-3-4	0				
20										
6				Medium stiff brown lean CLAY with gray siltseams (CL)	3-4-5-6	0				
25										
7				Medium brown sandy lean CLAY with organics (CL)	4-4-4-4	0				
30										
8				Hard LIMESTONE	50/0	0				
35										
40				Auger Refusal at 32.8 ft						

LABORATORY LOG OF BORING NUMBER: B-4					PROJECT: USCG Base St. Louis					
CLIENT: United States Coast Guard					BORING DEPTH: 35 ft					
LOCATION: Foot of Iron Street, St. Louis Mo.					BORING DATE: January 22, 1992					
DRILLING METHOD: Hollow stem auger					ENCOUNTERED WATER: 9.5 ft					
SURFACE ELEVATION:					WATER ON COMPLETION: N/A					
					WATER AFTER HRS.: N/A					
D E P T H (ft)	S A M P L E	T Y P E	S Y M B O L	SOIL DESCRIPTION	STANDARD PEN. blows/6 in.	PID RESULT (ppm)	DRY UNIT WEIGHT (pcf)	PL (%)	WC (%)	LL (%)
1				FILL: Gravel (12")						
5				FILL: Black stained sand with slag	5-6-5-4	25				
2					1-4-2-1	40				
3				FILL: Slag and gravel, oil stained, solvent odor	11-11-11- -20	90				
10										
4				Loose brown medium SAND, wet (SP)	3-3-4-5	175				
15				Loose gray lean CLAY, chlorinated solvent odor (CL)						
5				Loose gray sandy SILT (ML)	3-4-5-5	70				
20										
6					3-3-5-6	5				
25										
7				Loose gray SILT, with wood fragments, creosote odor (ML)	2-3-3-4	9				
30										
8				Moderately hard weathered LIMESTONE	56/6"	0				
35										
40				Auger Refusal at 35 ft						

LABORATORY LOG OF BORING NUMBER: B-5					PROJECT: USCG Base St. Louis					
CLIENT: United States Coast Guard					BORING DEPTH: 33.5 ft					
LOCATION: Foot of Iron Street, St. Louis Mo.					BORING DATE: January 23, 1992					
DRILLING METHOD: Hollow stem auger					ENCOUNTERED WATER: 18 ft					
SURFACE ELEVATION:					WATER ON COMPLETION: N/A					
D E P T H (Ft)	S A M P L E	T Y P E	S Y M B O L	SOIL DESCRIPTION	STANDARD PEN. blows/6 in.	PID RESULT (ppm)	DRY UNIT WEIGHT (pcf)	PL (%)	WC (%)	LL (%)
				1" Asphalt, 3" Concrete						
1				FILL: Slag and gravel	8-9-3-3	5				
5					3-3-3-4	6				
10				FILL: Slag, sand, and gravel	7-50/6"	6				
15				FILL: Bricks, slag, and sand	3-6-9-18	6				
20					52/6"	5				
25					50/1"	2				
30					50/5"	4				
35				Moderately hard weathered LIMESTONE	50/4"	0				
40				Auger Refusal at 33.5 ft.						

LABORATORY LOG OF BORING NUMBER: B-6					PROJECT: USCG Base St. Louis					
CLIENT: United States Coast Guard					BORING DEPTH: 25 ft					
LOCATION: Foot of Iron Street, St. Louis Mo.					BORING DATE: January 23, 1992					
DRILLING METHOD: Hollow stem auger					ENCOUNTERED WATER: 22 ft					
SURFACE ELEVATION:					WATER ON COMPLETION: N/A					
					WATER AFTER HRS.: N/A					
D E P T H (ft)	S A M P L E	T Y P E	S Y M B O L	SOIL DESCRIPTION	STANDARD PEN. blows/6in.	PID RESULT (ppm)	DRY UNIT WEIGHT (pcf)	PL (%)	WC (%)	LL (%)
				6" Topsoil						
1				FILL: Slag and gravel.	10-50/6"	0				
5	2				50/1"	0				
10	3				50/4"	0.				
15	4				50/1"	0				
20	5				50/1"	0				
25	6			Medium dense gray SILT with gravel, strong organic odor (ML)	6-12-9-8	0				
30										
35										
40										

LABORATORY LOG OF BORING NUMBER: B-7					PROJECT: USCG Base St. Louis					
CLIENT: United States Coast Guard					BORING DEPTH: 25 ft					
LOCATION: Foot of Iron Street, St. Louis Mo.					BORING DATE: January 24, 1992					
DRILLING METHOD: Hollow stem auger					ENCOUNTERED WATER: 19.9 ft					
SURFACE ELEVATION:					WATER ON COMPLETION: N/A					
DEPTH (ft)	SAMPLE E	TYPE	SYMBOL	SOIL DESCRIPTION	STANDARD PEN. blows/6in.	PID RESULT (ppm)	DRY UNIT WEIGHT (pcf)	PL (%)	WC (%)	LL (%)
				3" Concrete, no base						
1				FILL: Gravel and brown lean clay	50/6"	0				
5				FILL: Bricks, slag and glass	9-5-10-9	0				
10				FILL: Slag, sand, and clay, sulfur odor	8-9-9-16	0				
15					3-6-7-6	0				
20					12-9-6-7	0				
25				FILL: Gravel and loose black silt, strong organic odor	9-6-8-3	50				
30										
35										
40										

LABORATORY LOG OF BORING NUMBER: B-8					PROJECT: USCG Base St. Louis					
CLIENT: United States Coast Guard					BORING DEPTH: 25 ft					
LOCATION: Foot of Iron Street, St. Louis Mo.					BORING DATE: January 24, 1992					
DRILLING METHOD: Hollow stem auger					ENCOUNTERED WATER: 18 ft.					
SURFACE ELEVATION:					WATER ON COMPLETION: N/A					
					WATER AFTER HRS.: N/A					
D E P T H (ft)	S A M P L E	T Y P E	S Y M B O L	SOIL DESCRIPTION	STANDARD PEN. blows/6in.	PID RESULT (ppm)	DRY UNIT WEIGHT (pcf)	PL (%)	WC (%)	LL (%)
				3" Asphalt and concrete, 8" base						
1				FILL: Slag and gravel, sulfur odor	4-20-50/5"	0				
5					4-5-5-15	0				
					9-10-8-6	0				
10				FILL: Firm reddish brown fine sand						
					5-8-4-7	0				
15				FILL: Slag and gravel, sulfur odor						
					4-5-10-10	0				
20										
					2-2-2-1	0				
25				Loose gray SILT, wet (ML)						
30										
35										
40										

LABORATORY LOG OF BORING NUMBER: B-9					PROJECT: USCG Base St. Louis					
CLIENT: United States Coast Guard					BORING DEPTH: 25 ft					
LOCATION: Foot of Iron Street, St. Louis Mo.					BORING DATE: January 24, 1992					
DRILLING METHOD: Hollow stem auger					ENCOUNTERED WATER: 7 ft, 21 ft					
SURFACE ELEVATION:					WATER ON COMPLETION: N/A					
					WATER AFTER HRS.: N/A					
D E P T H (ft)	S A M P L E	T Y P E	S Y M B O L	SOIL DESCRIPTION	STANDARD PEN. blows/6in.	PID RESULT (ppm)	DRY UNIT WEIGHT (pcf)	PL (%)	WC (%)	LL (%)
				3" Concrete						
1				FILL: Hard brown and gray lean clay with slag	12-24-11-8	0				
5				FILL: Firm brown fine sand	6-10-7-7	0				
2				FILL: Brick fragments, slag, black stained sand	2-3-18-12	40				
3										
10										
4				FILL: Slag and gravel, very strong solvent odor	8-32-19-9	150				
15										
5					50/6"	300				
20										
6				FILL: Sand, slag, gray clay, and brick fragments	18-19-35 50/3"	300				
25										
30										
35										
40										

LABORATORY LOG OF BORING NUMBER: B-10					PROJECT: USCG Base St. Louis					
CLIENT: United States Coast Guard					BORING DEPTH: 20 ft					
LOCATION: Foot of Iron Street, St. Louis Mo.					BORING DATE: January 25, 1992					
DRILLING METHOD: Hollow stem auger					ENCOUNTERED WATER: 15 ft					
SURFACE ELEVATION:					WATER ON COMPLETION: N/A					
					WATER AFTER HRS.: N/A					
D E P T H (ft)	S A M P L E	T Y P E	S Y M B O L	SOIL DESCRIPTION	STANDARD PEN. blows/6in.	PID RESULT (ppm)	DRY UNIT WEIGHT (pcf)	PL (%)	WC (%)	LL (%)
				3" Concrete						
1				FILL: Medium sand and gravel, stained black	10-12-13-16	0				
5	2			FILL: Bricks, slag, and black stained sand	50/6"	6				
10	3				4-4-8-8	4				
15	4			FILL: Slag and foundry sand	27-35-12-8	7				
20	5			FILL: Sand, slag, loose gray Silt, wet, with sulfur odor	7-6-4-6	12				
25										
30										
35										
40										

LABORATORY LOG OF BORING NUMBER: B-12					PROJECT: USCG Base St. Louis					
CLIENT: United States Coast Guard					BORING DEPTH: 20 ft					
LOCATION: Foot of Iron Street, St. Louis Mo.					BORING DATE: January 29, 1992					
DRILLING METHOD: Hollow stem auger					ENCOUNTERED WATER: 10 ft					
SURFACE ELEVATION:					WATER ON COMPLETION: N/A					
					WATER AFTER HRS.: N/A					
D E P T H (Ft)	S A M P L E	T Y P E	S Y M B O L	SOIL DESCRIPTION	STANDARD PEN. blows/6in.	PID RESULT (ppm)	DRY UNIT WEIGHT (pcf)	PL (%)	WC (%)	LL (%)
				12" Topsoil						
1				FILL: Brown sandy clay	3-3-3-2	0				
5				FILL: Brown sand and gravel	2-2-2-2	0				
10					12-7-3-2	0				
15				FILL: Brown medium sand	3-4-7-7	0				
20				Medium dense gray sandy SILT (ML)	3-2-2-4	0				
25										
30										
35										
40										

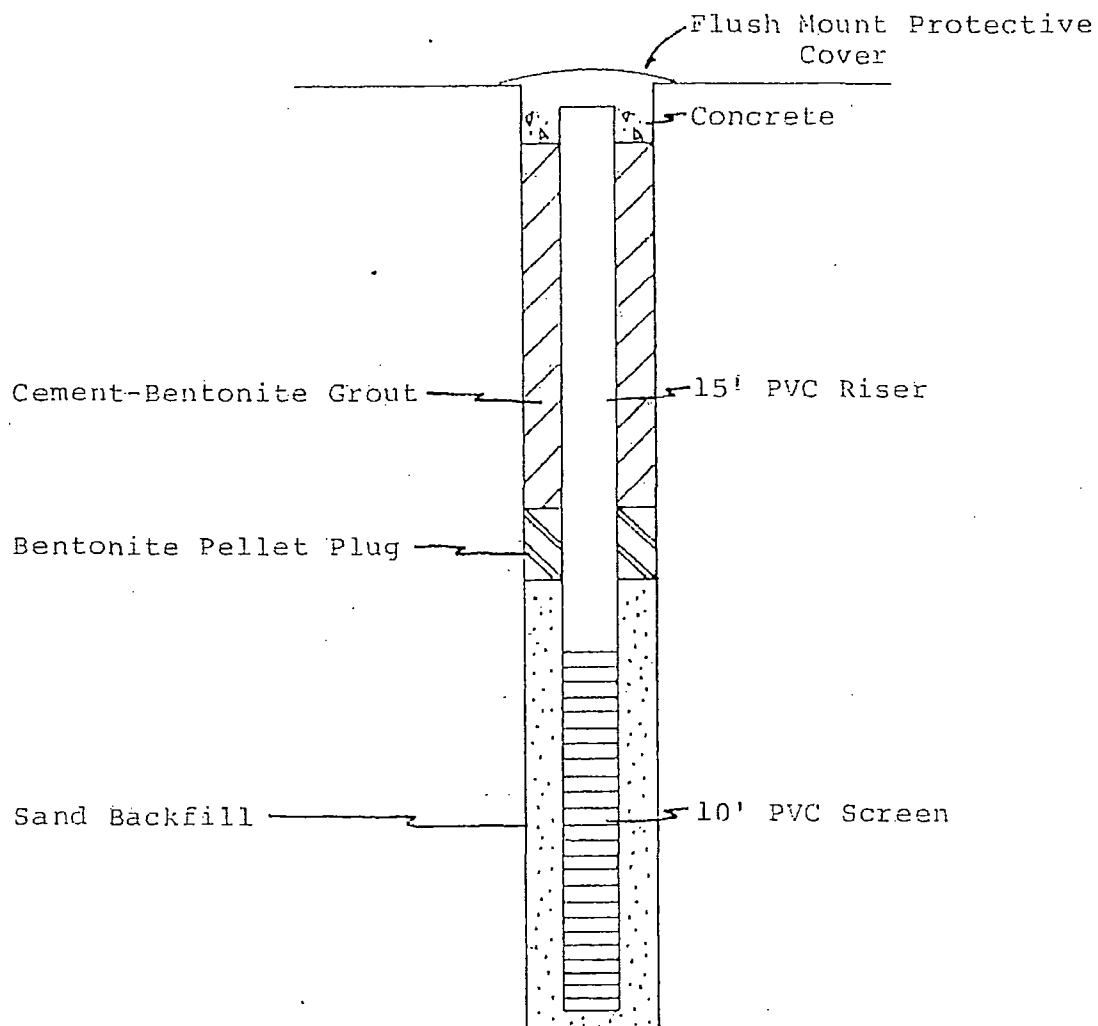
LABORATORY LOG OF BORING NUMBER: B-13					PROJECT: USCG Base St. Louis					
CLIENT: United States Coast Guard					BORING DEPTH: 20 ft					
LOCATION: Foot of Iron Street, St. Louis Mo.					BORING DATE: January 29, 1992					
DRILLING METHOD: Hollow stem auger					ENCOUNTERED WATER: 20 ft					
SURFACE ELEVATION:					WATER ON COMPLETION: N/A					
					WATER AFTER HRS.: N/A					
D E P T H (ft)	S A M P L E	T Y P E	S Y M B O L	SOIL DESCRIPTION	STANDARD PEN. blows/6in.	PID RESULT (ppm)	DRY UNIT WEIGHT (pcf)	PL (%)	WC (%)	LL (%)
				12" Topsoil						
1				FILL: Brown sandy clay	4-6-4-9	0				
5				FILL: Medium sand, stained black						
2				FILL: Blue foundry stone, sand, and clay	2-1-2-5	0				
3				Medium dense gray SILT with organics (ML)	3-2-3-5	0				
10										
4				Stiff brown and gray silty CLAY (CL-ML)	3-5-7-9	0				
15										
5				Medium brown sandy SILT (ML)	2-2-3-2	0				
20										
25										
30										
35										
40										

LABORATORY LOG OF BORING NUMBER: B-14					PROJECT: USCG Base St. Louis					
CLIENT: United States Coast Guard					BORING DEPTH: 35 ft					
LOCATION: Foot of Iron Street, St. Louis Mo.					BORING DATE: January 29, 1992					
DRILLING METHOD: Hollow stem auger					ENCOUNTERED WATER: 19 ft					
SURFACE ELEVATION:					WATER ON COMPLETION: N/A					
					WATER AFTER HRS.: N/A					
D E P T H (ft)	S A M P L E	T Y P E	S Y M B O L	SOIL DESCRIPTION	STANDARD PEN. blows/6in.	PID RESULT (ppm)	DRY UNIT WEIGHT (pcf)	PL (%)	WG (%)	LL (%)
				12" Topsoil						
1				FILL: Brown lean clay, coal, sand, slag, and blue foundry stone	10-14-13-18	4				
5					50/5"	7				
2					6-10-4-5	0				
3										
10										
4					4-4-4-5	0				
15										
5				Medium dense gray sandy SILT with organics (ML)	7-8-4-4	0				
20										
6					4-5-7-5	0				
25										
7					9-33-17-10	0				
30										
8				Moderately hard LIMESTONE	50/1"	0				
35				Auger refusal at 33 ft						
40										

LABORATORY LOG OF BORING NUMBER: B-15					PROJECT: USCG Base St. Louis					
CLIENT: United States Coast Guard					BORING DEPTH: 20 ft					
LOCATION: Foot of Iron Street, St. Louis Mo.					BORING DATE: January 29, 1992					
DRILLING METHOD: Hollow stem auger					ENCOUNTERED WATER: NO WATER ON COMPLETION: N/A WATER AFTER HRS.: N/A					
SURFACE ELEVATION:										
D E P T H (ft)	S A M P L E	T Y P E	S Y M B O L	SOIL DESCRIPTION	STANDARD PEN. blows/6in.	PID RESULT (ppm)	DRY UNIT WEIGHT (pcf)	PL (%)	WC (%)	LL (%)
1				12" Topsoil						
5				FILL: Brown lean clay, coal, sand, slag, and blue foundry stone	40-20-32-35	5				
2					23-10-7-8	0				
10				FILL: Slag and blue foundry stone	6-50/3"	7				
15					19-17-50/3"	0				
20					50/3"	0				
25										
30										
35										
40										

LABORATORY LOG OF BORING NUMBER: B-16					PROJECT: USCG Base St. Louis					
CLIENT: United States Coast Guard					BORING DEPTH: 20 ft					
LOCATION: Foot of Iron Street, St. Louis Mo.					BORING DATE: January 29, 1992					
DRILLING METHOD: Hollow stem auger					ENCOUNTERED WATER: 12 ft					
SURFACE ELEVATION:					WATER ON COMPLETION: N/A					
D E P T H (ft)	S A M P L E	T Y P E	S Y M B O L	SOIL DESCRIPTION	STANDARD PEN. blows/6in.	PID RESULT (ppm)	DRY UNIT WEIGHT (pcf)	PL (%)	WC (%)	LL (%)
				3" Concrete						
1				FILL: Sand, slag, and blue foundry stone	6-5-4-6-	0				
5					36-11-6-	0				
2					-16					
3				FILL: Slag and blue foundry stone	50/1"	7				
10										
4					1-2-5-10	20				
15				FILL: Slag and loose gray silt, solvent odor						
5					11-20-12-7	200				
20										
25										
30										
35										
40										

LABORATORY LOG OF BORING NUMBER: B-17					PROJECT: USCG Base St. Louis					
CLIENT: United States Coast Guard					BORING DEPTH: 32.3 ft					
LOCATION: Foot of Iron Street, St. Louis Mo.					BORING DATE: January 29, 1992					
DRILLING METHOD: Hollow stem auger					ENCOUNTERED WATER: 13.5 ft					
SURFACE ELEVATION:					WATER ON COMPLETION: N/A					
					WATER AFTER HRS.: M/A					
D E P T H (ft)	S A M P L E	T Y P E	S Y M B O L	SOIL DESCRIPTION	STANDARD PEN. blows/6in.	PID RESULT (ppm)	DRY UNIT WEIGHT (pcf)	PL (%)	WC (%)	LL (%)
				3" Concrete						
1				FILL: Clay, sand, and gravel	10-50/6"	2				
5	2				18-18-50/4"	3				
10	3			FILL: Slag and blue foundry stone	10-6-5-2	11				
15	4			FILL: Slag and loose gray Silt, solvent odor	1-3-2-4	5				
20	5			Loose moist gray SILT (ML)	2-2-3-3	0				
25	6				2-3-3-4	0				
30	7				1-2-2-3	0				
	8			Hard LIMESTONE	50/1"	0				
35				Auger Refusal at 32.3 ft						
40										

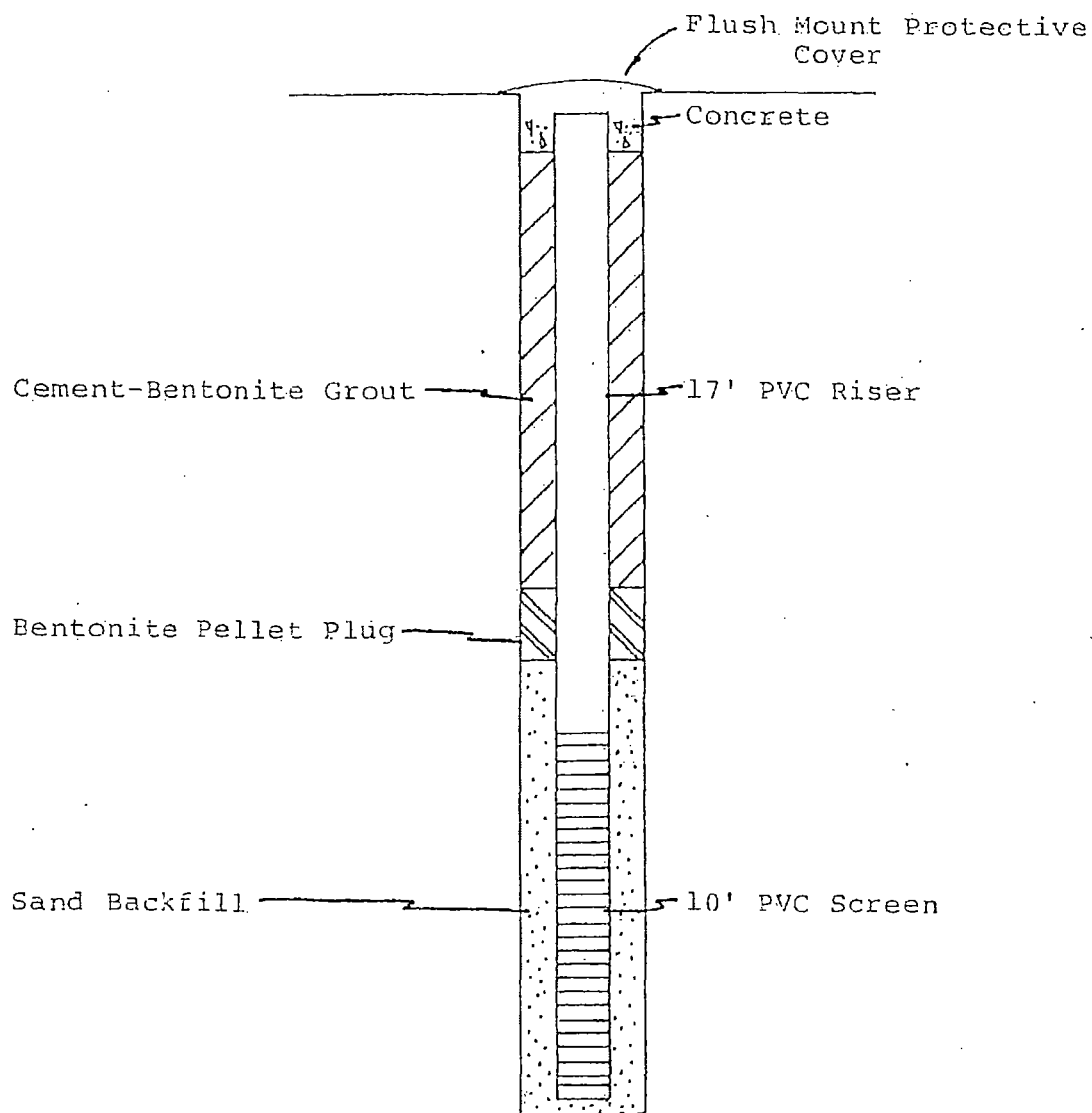


MONITOR WELL CONSTRUCTION DIAGRAM

MW-1
USCG Base St. Louis
St. Louis, Missouri

Scale: 1" = 5'

EDP Consultants, Inc.
February 12, 1992

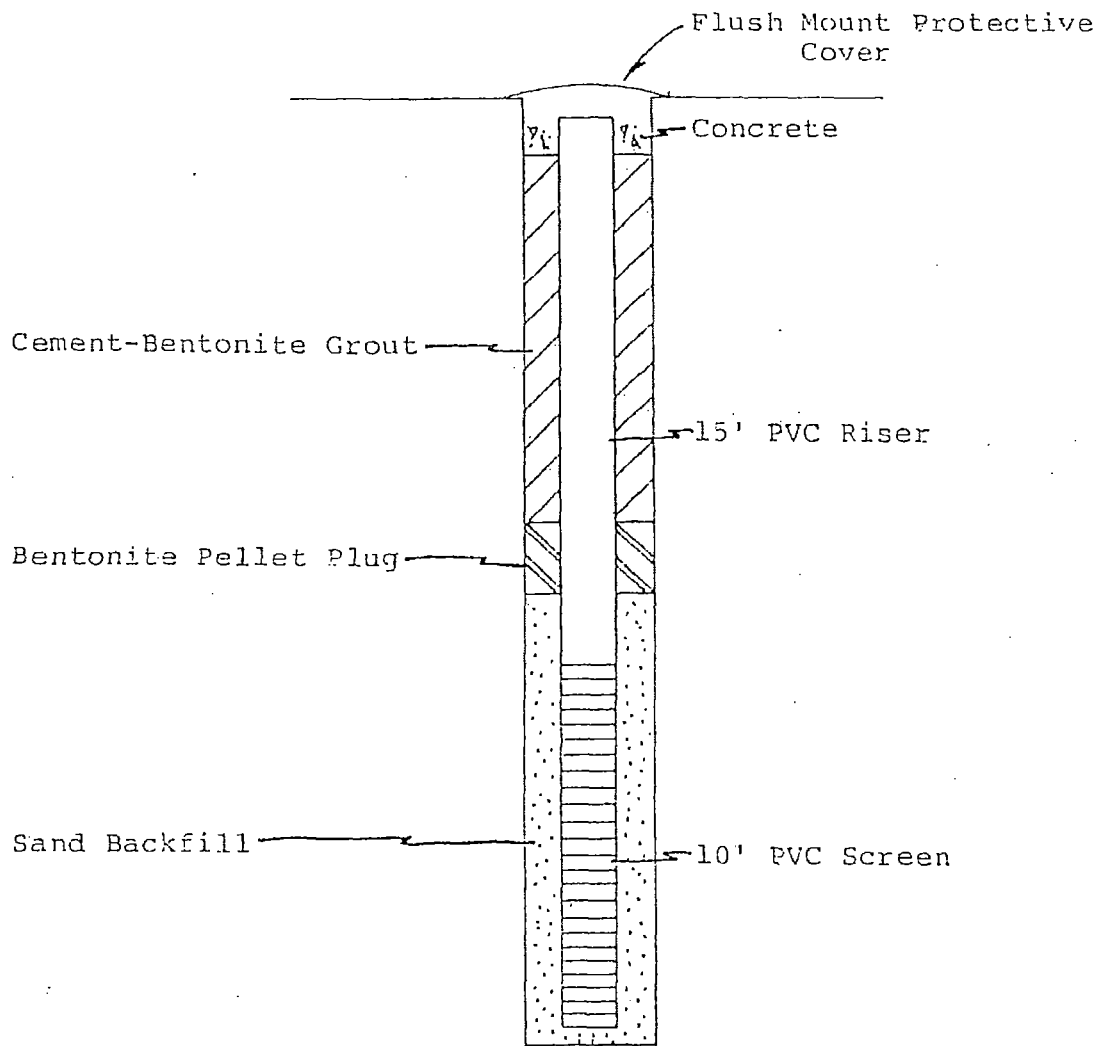


MONITOR WELL CONSTRUCTION DIAGRAM

MW-5
USCG Base St. Louis
St. Louis, Missouri

Scale: 1" = 5'

EDP Consultants, Inc.
February 12, 1992

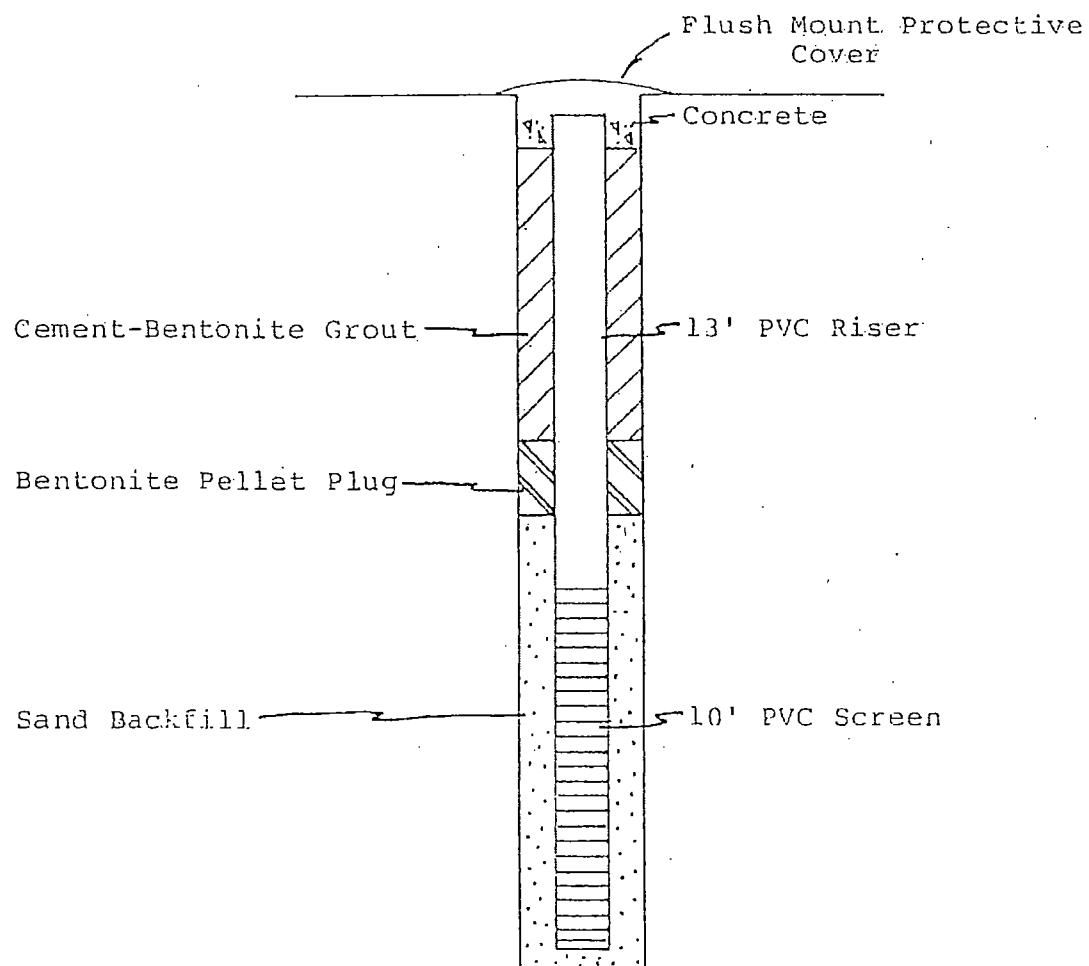


MONITOR WELL CONSTRUCTION DIAGRAM

MW-7
USCG Base St. Louis
St. Louis, Missouri

Scale: 1" = 5'

EDP Consultants, Inc.
February 12, 1992

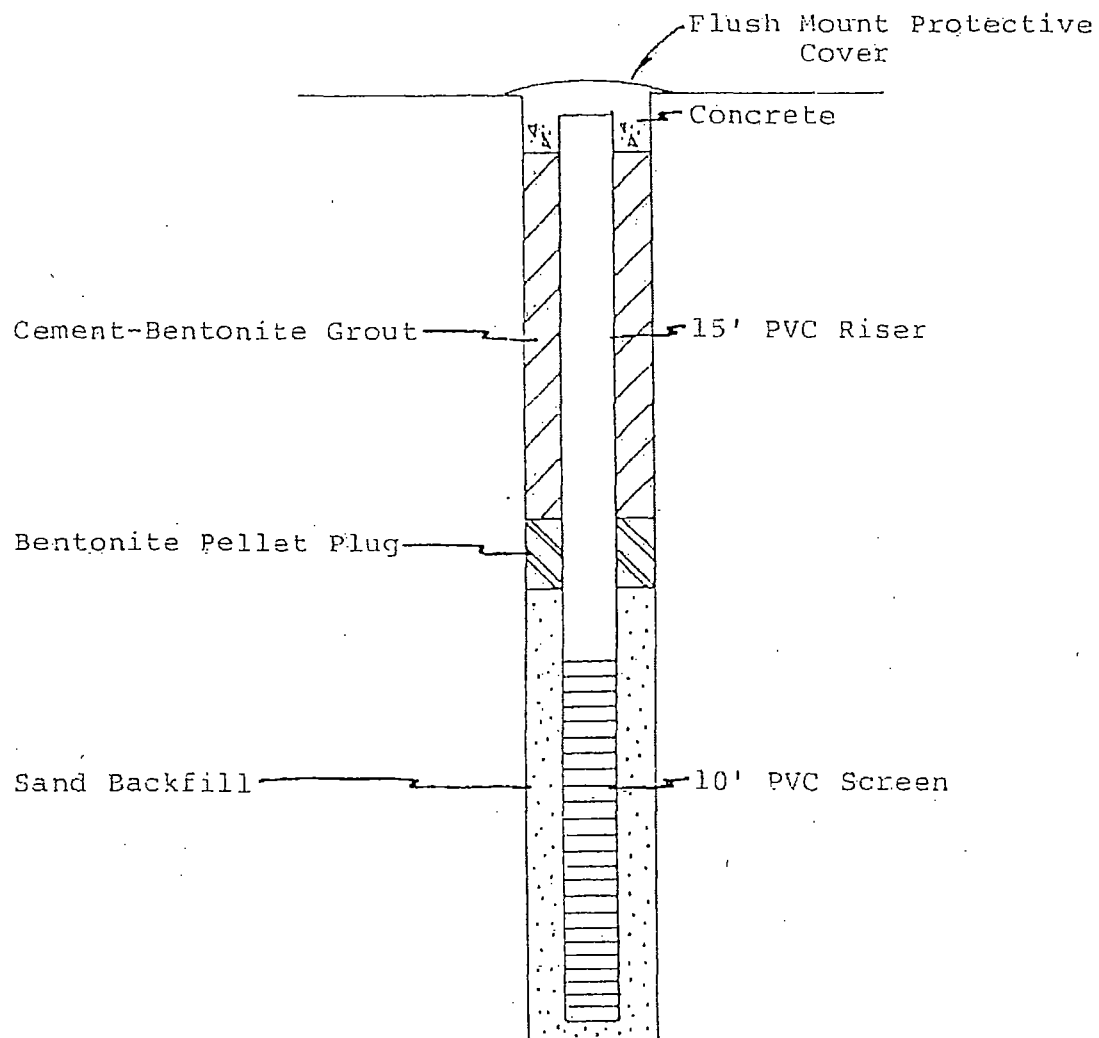


MONITOR WELL CONSTRUCTION DIAGRAM

MW-8
USCG Base St. Louis
St. Louis, Missouri

Scale: 1" = 5'

EDP Consultants, Inc.
February 12, 1992

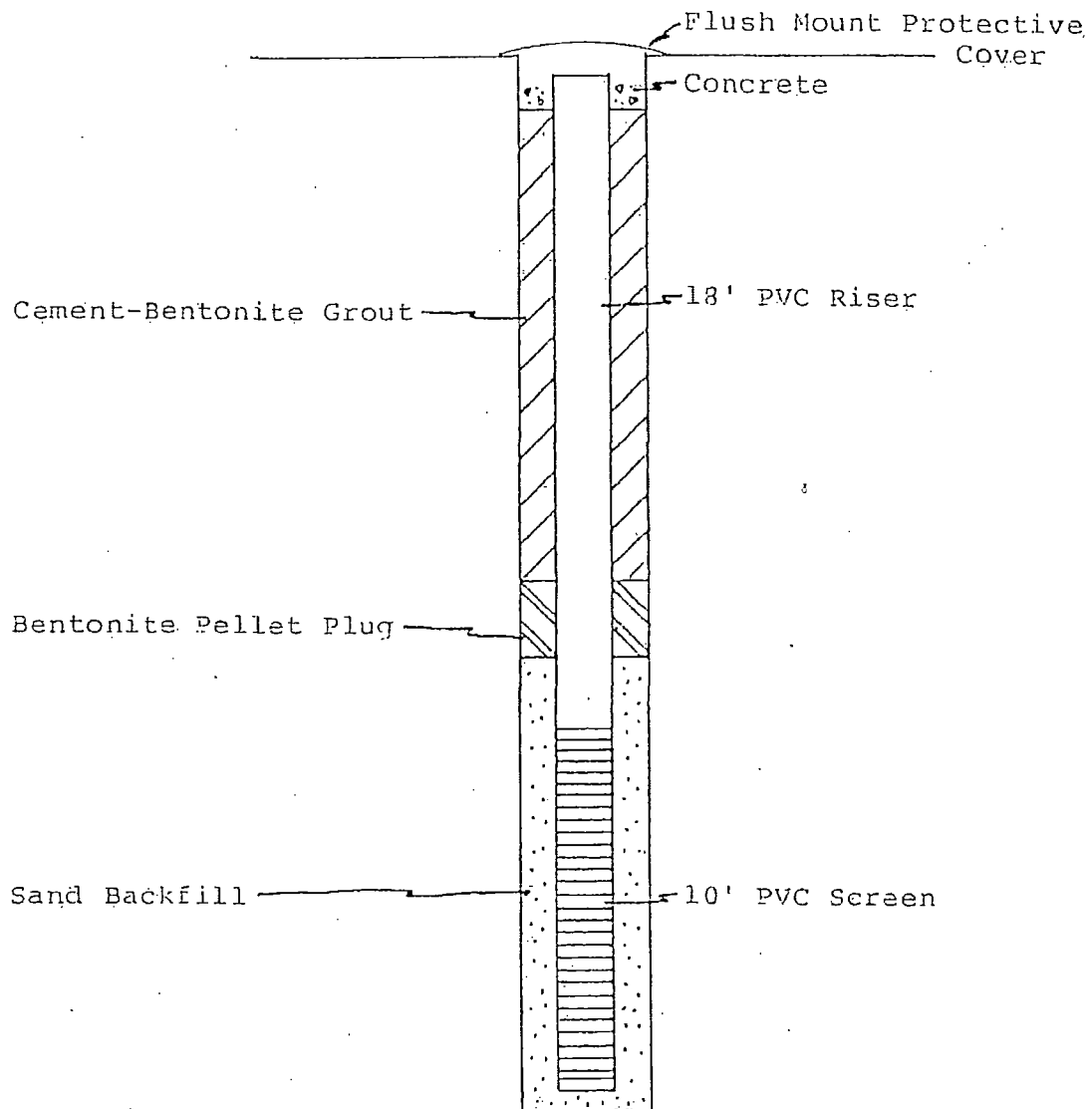


MONITOR WELL CONSTRUCTION DIAGRAM

MW-9
USCG Base St. Louis
St. Louis, Missouri

Scale: 1" = 5'

EDP Consultants, Inc.
February 12, 1992



MONITOR WELL CONSTRUCTION DIAGRAM

MW-11
USCG Base St. Louis
St. Louis, Missouri

Scale: 1" = 5'

EDP Consultants, Inc.
February 12, 1992

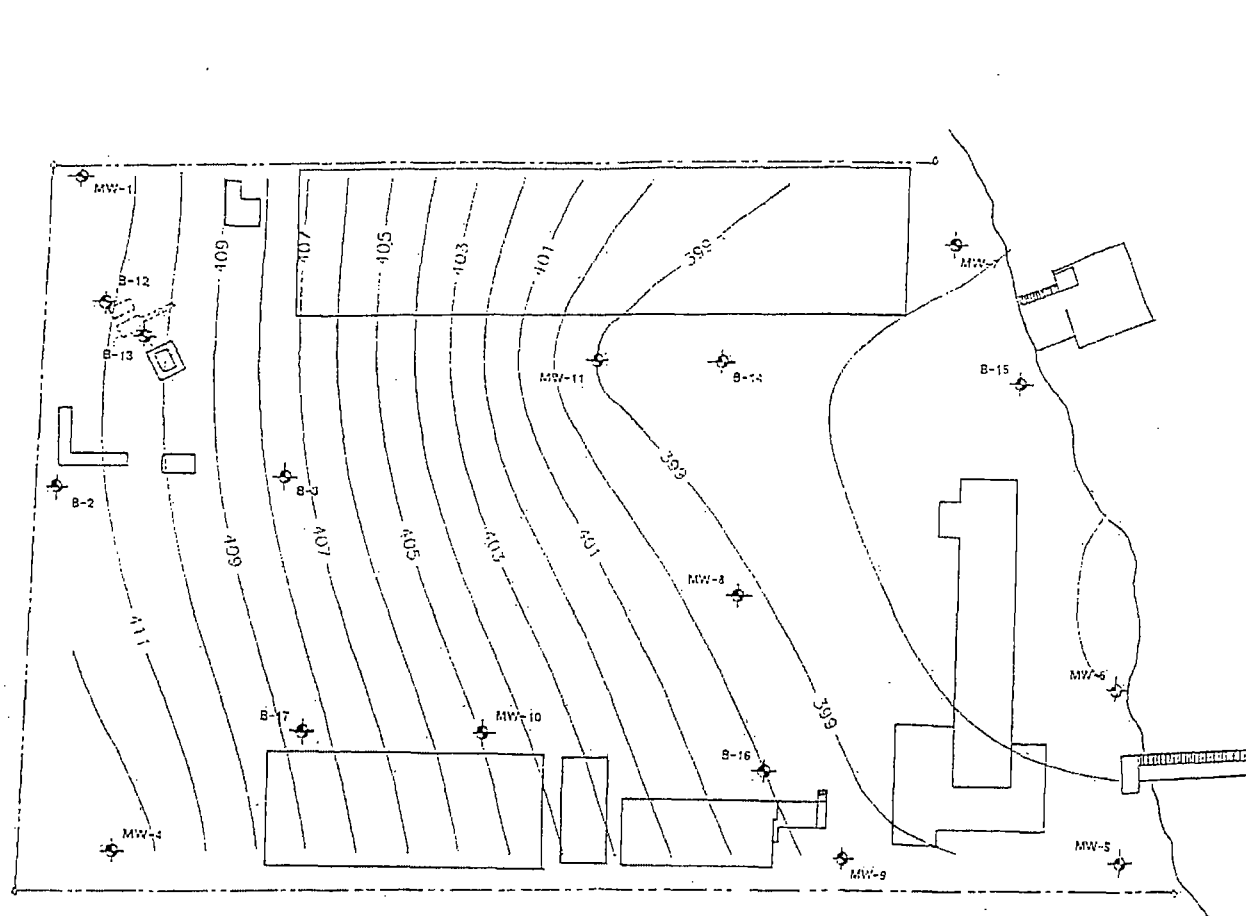


FIGURE 3: CONTOUR MAP OF ESTIMATED GROUNDWATER ELEVATIONS

USCG Base St. Louis
St. Louis, Missouri

Contour Interval: 1 foot
Approximate Scale: 1" = 60'

EDP Consultants, Inc.
March 6, 1992

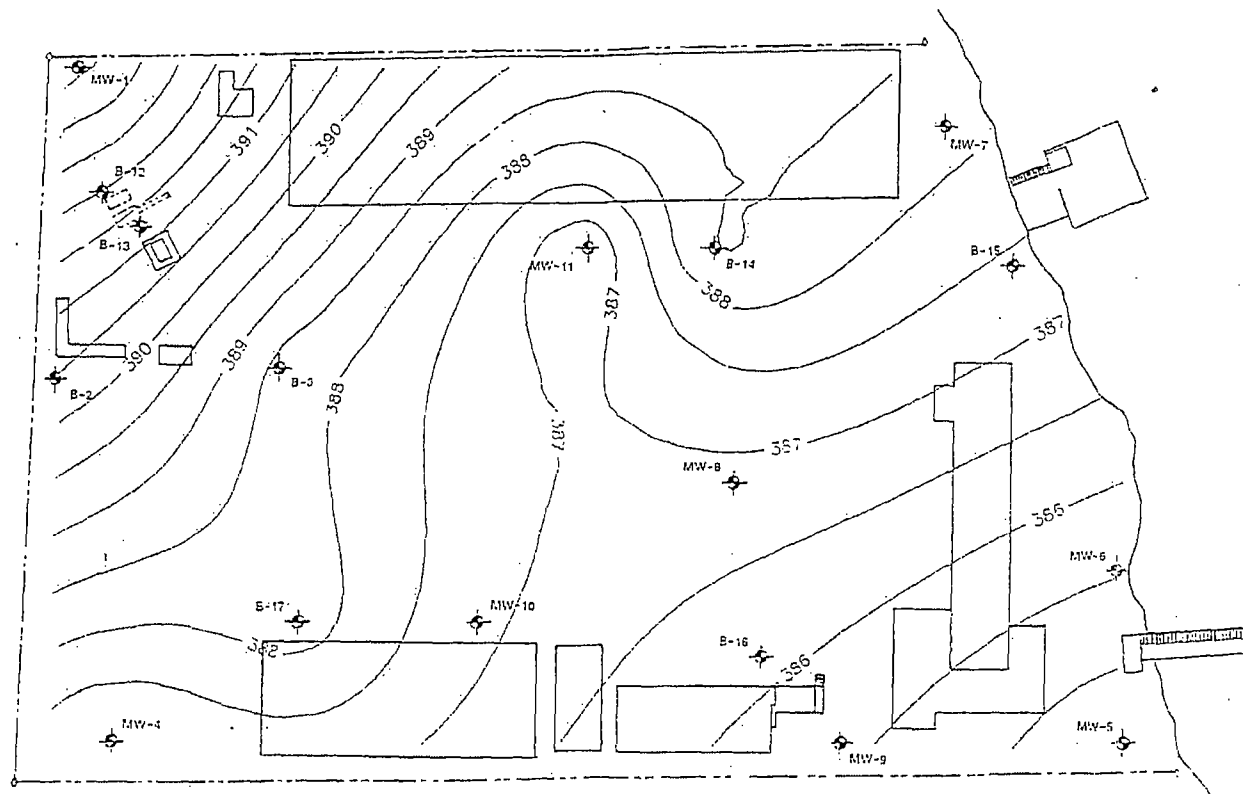


FIGURE 2: CONTOUR MAP OF ESTIMATED BEDROCK ELEVATIONS

USCG Base St. Louis
St. Louis, Missouri

Contour Interval: 0.5 feet
Approximate Scale: 1" = 60'

EDP Consultants, Inc.
March 6, 1992